"Experimental Determinations of Magnetic Susceptibility and of Maximum Magnetisation in Absolute Measure." By R. SHIDA, Thomson Experimental Scholar, University, Glasgow. Communicated by Sir W. THOMSON, F.R.S.

Received October 10, 1882. Read November 23, 1882.

[PLATES 9—16.]

The fact that there exists a limit to the magnetisation of a soft iron bar was first demonstrated by Joule, who, in 1840,* made a number of experiments on the sustaining power of an electro-magnet, and showed that when the current in the exciting coil is made stronger and stronger, that power tends to a certain definite value, or in other words, the magnetisation of the iron core attains a maximum.

In 1861, an interesting research on the magnetic properties of iron was made by Thalén, who determined, among other things, the magnetic susceptibility† of different specimens of soft iron in absolute measure for the first time. The units of length, mass, and time employed by Thalén were respectively a millimetre, a milligramme, and a second.

Joule and Thalén were followed by several, most of whom, however, made experiments without giving the results in absolute units; but amongst the few who have not overlooked the importance of such a system of units, Rowland made by far the most important investigations upon the subject. He determined not only the magnetic permeability or susceptibility of certain so-called magnetic bodies, but also the maximum magnetisation of those bodies in absolute units, using the metre, the gramme, and the second as the units of length, mass, and time.

The method of Thalén and that of Rowland are essentially the same, inasmuch as they depend upon the same electrodynamic principle, that an electric current induced in a closed circuit due to sudden creation or disappearance of magnetic lines of force, is proportional to the number of lines of force thus introduced or withdrawn, cutting the circuit. But one notable difference of the two methods lies in the fact that the one used ellipsoids or cylindrical rods of great length, while the other chiefly used rings or endless rods to experiment upon. The chief advantage of an electromagnetic method such as the above, is, as has been remarked by Sir William Thomson in his paper on the "Electrodynamic Qualities of Metals, Part VI,"‡ the ease and rapidity

* Joule's Collected Papers, page 34, from "Sturgeon's Annals," vol. v, page 187.

† Sir William Thomson, "Papers on Electricity and Magnetism," p. 472.

‡ "Phil. Trans.," 1876, p. 693.

with which the results can be obtained; while its disadvantage is revealed in the fact that it does not show either slow changes of magnetisation or the distribution of magnetism.

The following results of the experiments which have been made at the Physical Laboratory of the University of Glasgow, are given in absolute measure in which a centimetre, a gramme, and a second are taken as the units of length, mass, and time respectively, and were arrived at by means of the direct magnetometric method given to me by Sir William Thomson (who described and explained the method at the recent meeting of the British Association at Southampton in the Section A), as founded upon a method originated by Coulomb and discussed mathematically by Green. This method possesses some important advantages over the electromagnetic method; for instance, it shows at any moment any change of magnetisation of the body experimented on (which is of great practical utility in investigations of this kind); it affords an excellent means of illustrating the distribution of magnetism in the body, and it enables us to experiment upon a long thin bar, subjecting it to different strengths of magnetising forces, and to various amounts of longitudinal stress, and at the same time to determine in absolute measure, the magnetisation and magnetic susceptibility of the bar under these varied circumstances, which is an original feature of the investigations I am going to describe. These advantages, however, do not exist without disadvantages. That the execution of careful investigations involves a considerable amount of time, is a serious disadvantage of this method. After some preliminary studies, the orderly experiments were commenced about the middle of February last, and have since been carried on from day to day without intermission up to the end of May.

A number of thin wires and of thick bars of iron and steel were experimented upon. The accompanying sketch (Plate 9) shows the arrangement of the apparatus employed in experimenting on thin wires. A reflecting magnetometer, M, which consists of a mirror carrying at its back three small magnets and suspended by a single silk fibre about 5 centims. long, was placed on a convenient stand nearly 2 metres above the floor of the laboratory. S is a white paper screen divided into half millimetres, and bent into a circular arc of a metre radius. It is fixed at a distance of exactly 1 metre from the magnetometer, and was used to observe the deflections of the magnetometer needle, which were read by the image of a fine wire fixed vertically in front of a paraffin lamp, L, secured just behind the scale as in a Thomson reflecting galvanometer. N is a magnet of semicircular shape meant to control the strength of the field at the point where the magnetometer needle is suspended. It was mounted on a suitable stem in front of the magnetometer needle, with its length in the plane of the magnetic meridian, and at a certain distance

from the needle in such a way that the plane of the needle is unaltered by the magnet being removed or replaced when desired.

The wire to be experimented upon is represented by AA′. It is hung vertically at a distance of 10 centims. from, and due magnetic east of the magnetometer needle, by means of an arrangement of pulleys, P, P′, P″, and weights, W, W′, each weighing about half a kilogramme and attached to one end of the cords, T, T′, respectively as shown. In order that the wire may easily be detached from the cords, the other end of each cord, instead of being fastened directly to the end of the wire, is merely hooked, by a small brass hook which it carries, on to a loop of cord fastened to the end of the wire. The mode of fastening the loop of cord to the wire was as follows:—A cord 20 to 30 centims. long was made into a loop in such a way as to bring its ends together, and this latter part of the loop, after having been untwisted, was put over the end of the wire so as to enclose about 5 centims. of it in the untwisted portion, over which portion a thin string was tightly coiled a great number of times. This mode of fastening the cord to the wire allowed a heavy weight to be put on the wire without twisting or bending the latter in the slightest degree.

BB′ is the magnetising coil hung in such a manner from the string T that both its centre and axis coincide with those of the wire AA′. The coil used in the first part of the experiments was composed of only one layer of silk-covered copper wire wound on a straight brass tube of about 6 millims. in its internal diameter; the length of the coil was 108 centims., its radius was ·34 of a centimetre, and the number of turns of wire on the coil was 1,795, and the resistance of the coil including the electrodes was, at 14° C., 3·94 ohms. By means of this coil were obtained the results given in the columns headed 1 to 5 of the Table I. It was soon found that the coil just described was quite unsuitable for producing high magnetising forces, and that a modification was necessary. The coil, when modified, was 110 centims. long, and consisted of five layers of silk-covered copper wire laid on one above another; the radius of the innermost layer was ·340 of a centimetre, and that of the outermost was ·660 of a centimetre, and, therefore, the mean radius of the coil was ·50, and the mean distance between any two adjacent layers ·08 of a centimetre; the resistance of the coil, the electrodes included, was 30·8 ohms. at 14° C. The ends of the electrodes of the coil were permanently connected to the two terminals of a reversing key, K, the other two terminals of which were in connexion with the two electrodes of a Thomson tray battery so disposed that any desired number of cells, from 1 to 60 inclusive, could be placed in the circuit. A tangent galvanometer, G, was inserted in one of the connecting wires as shown in the sketch, so that whenever a current is passed through the

coil it was read and measured by this galvanometer. The weight W″ was simply used to balance the weight of the coil.

It will easily be seen from the arrangements of cords, pulleys, &c., that the wire, besides being kept straight, can be raised or lowered through any desired distance within a range of about 4 metres; and further, that when the wire is moved up or down the coil follows the movements, keeping its position with reference to the former unaltered. For the purpose of observing the position of the wire or the coil with great facility at any instant with reference to the line on a level with the magnetometer needle, there is provided, alongside the wire and coil, a scale divided into centimetres, and fixed to a wooden upright.

The orderly and systematic way in which the experiments were performed may be described generally thus:—A weight, the amount of which was different for different specimens of the wire as will be presently stated, was put on and taken off the wire, whilst the magnetising force was in action, about ten times in succession (this operation of successive application and removals of a weight will be hereafter called, for brevity, "ons and offs"), half a kilogramme being always on; then the wire, having been first placed so high up that its effect and that of the coil on the magnetometer was scarcely visible, was lowered 2 centims. by 2 centims., until it was so low down that little or no effect of the wire and coil was observable on the magnetometer, while the deflections of the magnetometer needle were noted for all the positions of the wire and coil. This process was followed in the case of all the wires, except the hard-tempered wire, and all the magnetising forces used, unless otherwise stated. It will be needless to enter into the discussion of the details of the object of subjecting the wire to the operations of "ons and offs," as they will be, I hope, shortly communicated to the Royal Society or elsewhere; suffice it to point out here that on commencing the preliminary experiments, it was soon discovered that in the first instance the wire was very irregularly magnetised, but that the effect of subjecting the wire, while under the influence of the vertical force, to the application and removal of a pull a certain number of times in succession, was to remove all the irregularities as to magnetisation, besides producing an enormous augmentation of its magnetism.

The results are given in the Tables I to IV. The general explanation of these and other accompanying tables is, that the "Distances" mean the distances of the centre of the wire from the level of the magnetometer needle, those distances measured from their level upwards being reckoned positive, and those measured downwards negative; while the "Deflections" mean the corresponding deflections of the needle in the scale-divisions—those deflections indicating the repulsion of the north-seeking pole, or red end of the needle, being

reckoned positive, and those indicating the attraction negative. The headings 1, 2, 3, &c., under "Deflections," are not only to show the order in which the experiments were performed, but to distinguish the results for one magnetising force from those for another; the exact value of the magnetising force in each case will be shown presently.

The first wire tried was a very soft iron (pure) wire,* supplied by Johnson and Nephew, Manchester, and is named in the table "Dark Wire," from its appearance. It was of No. 10 B.W.G., its breaking stress being about 15 kilogs. The piece experimented on was a metre long; its radius, when carefully calculated from its weight and specific gravity, was ·0374 of a centimetre, and therefore its sectional area was ·00439 square centim. The weight which was used for the operation of "Ons and Offs" was 8 kilogs., only with this exception, that at the beginning, while the force magnetising the wire was that due to the vertical component of the earth's magnetism alone, a weight of 10 kilogs. was put on once or twice. The wire underwent an elongation of 2·9 per cent. of its original length, so that it was now 102·9 centims., and its sectional area ·00425 square centim.; the elongation was permanent and constant, that is, the subsequent application of 8 kilogs. produced no more effect as to elongation. The results for this wire are shown in the Table I. In this table, the results under the heading numbered 1, which are those for the Glasgow vertical force, it must be mentioned, were obtained after the wire had been treated in the following manner:—The operation of "Ons and Offs," of a weight of 8 kilogs., having been performed while the wire was hanging one way, say, with the end A up, its magnetisation was observed in the manner explained before; the wire was then inverted, and the operation of "Ons and Offs" was again performed while it was hanging with the end A′ up, that is while the vertical force was acting in the opposite direction with respect to the wire, and its magnetisation was again observed; this process was repeated until the magnetisation of the wire in the two cases was equal, or nearly so, in intensity, but opposite in polarity. The first and second columns under any of the headings numbered 1 to 8 give the result obtained in the two cases respectively: (1) while a weight of 8 kilogs. was actually hanging on the wire (a case to be hereafter denoted by "On"), and (2) while the weight was off (a case to be hereafter denoted by "Off"); and the third column, if any, contains the result obtained for the effect of the coil alone carrying a current. The first column under 12 and 13 contains the result obtained (in the case "Off") immediately after reversing the current in the coil, the operation of "Ons and Offs" having been of course performed before the current was reversed; while the second and

* This wire is of the same kind as that used in the experiments described in Sir William Thomson's paper, "On the Electrodynamic Qualities of Metals, Part VII."

third columns contain the results obtained after the wire had been subjected to "Ons and Offs," when the reversed current was circulating through the coil, the former corresponding to the case "On" and the latter to the case "Off." The first column in the rest, that is, 14 to 17, is subject to the same explanation as the first column in 12 and 13; while the second column contains the result obtained in the same way as the third column in 12 and 13.

The next wire experimented on was also a pure soft iron wire, but not so soft as the last one; it is marked "Bright Wire"* in the tables. Its gauge is about No. 20 B.W.G., and its breaking stress is about 20 kilogs. The piece experimented on was also a metre long; its radius was ·0450 of a centimetre, and therefore its sectional area ·006362 square centim.; 12 kilogs. weight was employed for "Ons and Offs." The wire elongated 6·2 per cent. of its length, so that now its length was 106·2 centims., and remained so during all the rest of the experiment; the area of its cross-section being now ·00599 square centim. The Table II refers to this wire. As regards the first and second columns headed 1 under Deflection, exactly the same remark applies to this table as to the last table. The first and second columns under any of the headings give the results in the cases of "On" and "Off" respectively; and the third and fourth columns give the results (both in the case of "Off") obtained, the former immediately after reversing the current in the coil, and the latter after the operation of "Ons and Offs" had been performed while the reversed current was kept flowing through the coil.

The Table III contains the results for the "Steel Pianoforte Wire," which was of the same gauge as the "Dark Wire," and which is largely used in Sir William Thomson's sounding machines. The breaking weight of this wire is said to be roughly 100 kilogs. The length of the piece of the wire experimented on was a metre; its radius was ·03755 of a centimetre, and therefore the area of its cross-section was ·004452 square centim. A weight of 16 kilogs. was always used for "Ons and Offs." No elongation of the wire was observed. To both the first and second columns under all the headings in the Table III precisely the same remarks apply as to those in the preceding tables; while the third column, should there be one, gives the result for the coil alone.

The last of the thin wires experimented on was a glass-hard-tempered steel wire, the results of which are exhibited in the Table IV. The mode of tempering which was adopted is perhaps worthy of a passing notice. A convenient length was cut from the same hank as the preceding

* Further particulars regarding the elasticity, &c., of this wire are found in Mr. J. T. Bottomley's interesting paper on the "Effects of Long-continued Stress on the Elasticity of Metals," "Proc. Roy. Soc.," vol. xxix (1879), p. 221.

wire (pianoforte wire); and while held horizontally by means of pliers over a tray containing cold water, it was raised to a bright red heat by passing through it a strong current from a Faure battery, and suddenly plunged into the tray. This plan proved a complete success, the heat being equally distributed throughout the whole mass of the wire; the tempering was, of course, as uniform as it could be all over the length of the wire, perhaps, with the exception of the ends where it was held. When short pieces were cut off from the extremities, the wire was 78·42 centims. long; the area of its cross-section was now ·004326 square centim., the wire having lost nearly 2 per cent. of its weight by the process of tempering. This wire was, of course, so exceedingly brittle that the operation of "Ons and Offs" of a heavy weight was an impossibility, and consequently no weight was put on the wire at all, except those used to keep it vertically straight. With reference to the explanation of the Table IV, the first column in 1, 2, 3, &c., refers to the result arrived at when the magnetising force was kept acting on the wire; and the second column, if there be one, refers to the result arrived at directly after the withdrawal of all magnetising force, except that due to the vertical component of the earth magnetism.

Somewhat thick bars of cast iron, hard-tempered steel, and soft iron, were then procured and experimented upon, with a view to determine approximately the law of magnetisation of those bars, and to compare the results with each other and with those for the wires. The bars were nearly equal in their dimensions; they were all 61 centims. in length and very nearly square in section; the sectional area of the cast-iron bar, when calculated from its weight and specific gravity, was approximately ·950 square centim., that of the steel bar ·948 square centim., and that of the soft iron bar ·901 square centim.

With regard to the mode of experimenting in the case of these bars, though it remained the same in principle as before, it necessarily differed in details, which I proceed to describe thus:—In the first place, the coil employed for magnetising the bars was 68 centims. long, and consisted of three layers of insulated copper wire wound on a tube of copper nearly square, each layer containing 620 turns; the whole area inclosed by all the turns of wire per unit length was 89 sq. centims. approximately, though not very accurately on account of the difficulty of measuring exactly the dimensions of the coil, as it was not specially made for the purpose; and the resistance of the coil was about 3·78 ohms when cool. The bar to be experimented on was placed inside the coil, with its centre and axis coincident with those of the latter; and the whole arrangement thus fitted up was hung vertically in the same way as before by means of cords, pulleys, &c., with the common axis of the coil and the bar at a distance of 22 centims. from, and due magnetic east of, the magnetometer; the con-

nexions of the electrodes of the coil, the galvanometer, &c., being precisely the same as before.

The same procedure in experimenting as before was followed as far as possible; that is to say, the bar and the coil, having been placed high up to begin with, were lowered 2 centims. by 2 centims. until they were low down, while the deflections of the magnetometer needle were read for all the positions of the bar or the coil. In the case, however, where this procedure was hardly possible, or, at any rate, hardly worth going through, on account of the rapid variation of the current in the coil, arising partly from the heating up of the coil and partly from the polarisation of the battery (which consisted either of the Thomson tray, Daniell's, or of the Faure accumulators, the latter being chiefly used to obtain very high magnetising forces), the experiment was made in the following manner:—A point of the bar, 28 centims. distant from its centre, having been placed on a level with the magnetometer needle (as this position of the bar was such as to give the needle a maximum deflection for a high magnetising force), a strong current was allowed to pass through the coil, and as soon as the deflection of the needle was readable with a tolerable accuracy it was read off at a certain moment by one observer, while the strength of the current was measured by taking the reading of the galvanometer at the same moment by another observer on word of command from the former; the data thus obtained will, as we shall see, afford the means of determining approximately the magnetisation of the bar.

The results of experiments on the bar of cast iron, steel, and malleable iron, are given in the Tables V, VI, VII respectively, the general explanation of which has been already given in dealing with the other tables. The first column under any of the headings 1, 2, 3, &c., in each of the Tables V, VI, VII, contains the results obtained while the magnetising force was in action; while the second column, if there be one, contains the result obtained directly after the withdrawal of the force.

Now the best way to study the results given in all the Tables I to VII, is to plot curves in such a manner that the ordinates represent the "Distances" of the centre of the wire or bar from the datum line, the level of the magnetometer needle, and the abscissæ represent the "Deflections" of the needle in the scale divisions. To illustrate this, the results shown in the second and third columns under 7, Table I, are exhibited by the curves 1 and 2 respectively, Plate 10, in which those distances measured upward from the datum line are reckoned positive and those measured downwards negative; while those deflections indicating the repulsion of the red end of the needle are reckoned positive, and those indicating the attraction negative, according to the convention already adopted.

Table I.—Dark Wire.

Distances.	Deflections.																
	1.		2.		3.		4.		5.		6.*	7.			8.		
100	4	2	4	3	6	4	1	+ 0·5	1·5	1·5	2	2	2	1	2·5	2·5	1·5
90	6	3	8	6·5	10	9	2	1·5	2·5	2·5	4·5	5	5	2·5	5·5	5·5	3
80	10	4	19	16	25	23	4	3·5	5	5	9	11	11·5	5·5	13·5	13·5	8
70	28	12	59	45	79	69	10	9·5	14·5	15	26	34	34·5	18	42	43	24
68	34	18	74	60	104	93	14	13·5	19	22	36	46	47	25	56	57	32
66	43	22	92	78	134	120	18	17·5	25	27·5	48	59	60·5	32·5	73	74	41
64	55	30	118	106	182	170	24	23	34	37	63	81	82	45	97	98	57
62	71	38	149	138	236	223	31	30	43·5	46·5	84	104	106	58	125	126	74
60	96	50	202	186	319	290	41	40	56·5	61·5	110	135·5	138	74·5	162	167	98
58	125	68	271	2[illegible]9	438	390	54·5	53	73	80·5	139	171·5	174	91	203	208	118
56	166	96	359	334	526	502	69·5	68	93	102	165	200	203	101·5	235	240	134
54	218	124	440	418	702	596	83	81	110·5	117·5	180	215	217·5	102	248	253	134
52	266	152	504	450	783	646	91	91	119·5	124·5	179	211	214	92	241	244	120
50	318	172	543	463	805	652	91	90	118	121·5	165	191	193	75·5	214	217	98
48	342	184	536	407	749	601	81·5	81	104	107·5	140	160	161	60	176	177	78
46	348	186	476	325	643	465	67·5	66	85	86·5	110	124	125	47	135·5	136·5	56
44	330	164	403	219	494	332	51·5	49·5	65·5	67·5	82	95	96	35	102	103	44
42	298	140	323	120	369	219	39·5	37	50	52	65	72	73	27	76	77	34
40	260	104	250	62	276	140	28	26	38	38·5	47·5	50·5	51·5	21	56	57	25
38	220	80	191	40	214	109	21	20	30	30	37	40	40	16	44	45	19
36	178	61	151	18	153	71	16	14·5	23	23	28·5	30	30	12·5	33	34	15
34	148	45	110	12	120	58	12	11	19	19	23	24	24	9	26	26	13
32	114	30	85	5	88	46	9	8·5	15·5	15·5	19·5	18·5	18·5	7	20	20	11
30	92	20	69	4	69	33	7·5	7	12·5	12·5	16	15	15	6	17	17	10
28	74	11	52	2	51	26	6	5·5	10	10	13	12	12	4·5	13	13	8
26	60	5	42	2	39	18	4·5	4	7·5	7·5	11·5	9·5	9·5	3·5	10	10	7
24	45	0	31	1	27	12	3	2·5	5·5	5·5	10·5	7·5	7·5	3·5	7·5	7·5	6
22	37	0	24	1	16	5	1·5	1	4	4	7·5	6	6	3·5	6	6	6

* The first column under 6 being blank is omitted in printing.

Table I (continued).—Dark Wire.

Distances.	Deflections.																
	1.		2.		3.		4.		5.		6.*	7.			8.		
20	30	0	18	0	6	0	1	0	2·5	2·5	5	4·5	4·5	3	4·5	4·5	5·5
18	22	1	13	−1	+1	−5	0·5	−0·5	2	2	4	3	3·5	3	3	3	5
16	15	1	8	−2	−3	−11	0	−1	1	1	3·5	2	3	3	2	2	4
14	9	3	5	−2	−3	−12	0	−1	0·5	0·5	3	1·5	3·5	3	1·5	1·5	4
12	4	4	3	−3	−7	−13	0	−0·5	0	0	2·5	1	3	2·5	1	1	3
10	+1	5	4	−4	−3	−10	0	0	0·5	0·5	2	1	3	2·5	1	1	3
8	−3	6	5	−5	+1	−6	0·5	0·5	2·0	2	2	1	3	2	1	1	3
6	−5	7	6	−5	+5	−4	0·5	0·5	2·5	2·5	1·5	0·5	2·5	2	1	1	2
4	−8	6	7	−6	8	−2	1·5	1	3	3	1·5	0	1	1	+0·5	+0·5	1
2	−10	4	6	−8	5	−5	+0·5	0·5	2·5	2·5	0	−1·5	+0·5	1	−1	−1	0·5
0	−12	+2	+4	−9	+5	−9	0	0	+1	1	−1	−2	−2	+0·5	−2	−2	0
−2	−13	0	0	−11	−2	−12	0	−0·5	0	0	−1·5	−4	−3	+0·5	−5	−5	−1
−4	−15	−2	−4	−12	−7	−15	0	−1	−1	−1	−2	−5	−5	0	−7	−7	−2
−6	−15	−4	−8	−12	−12	−17	−1·5	−1·5	−1·5	−1·5	−2·5	−6	−6	−1	−8	−8	−2·5
−8	−15	−7	−13	−11	−17	−19	−2	−2	−2	−2	−3·5	−7	−7	−1	−9	−9	−3
−10	−16	−8	−15	−10	−18	−16	−2	−2	−2·5	−3·5	−4	−7·5	−7·5	−1	−9·5	−9·5	−3·5
−12	−16	−9	−17	−8	−20	−14	−2·5	−2	−3	−4·5	−4·5	−8	−8	−1	−10	−10	−3·5
−14	−17	−8	−18	−6	−19	−10	−2	−1·5	−3	−4	−5	−8·5	−8·5	−1	−10·5	−10·5	−4
−16	−18	−7	−19	−4	−19	−6	−1·5	−1	−3	−4	−5	−9	−9	−1·5	−11	−11	−4
−18	−19	−6	−23	−3	−21	−3	−1	−0·5	−2·5	−3·5	−5	−8·5	−8·5	−2	−10·5	−10·5	−4·5
−20	−21	−7	−29	−2	−23	−1	−0·5	−0·5	−2	−3	−5·5	−8	−8	−2	−10	−10	−5
−22	−26	−9	−28	−3	−20	−3	−1	−1	−1·5	−2·5	−6·5	−8	−8	−2·5	−10	−10	−5·5
−24	−31	−11	−28	−4	−15	−5	−0·5	−1	−1	−2·5	−7·5	−8	−8	−2·5	−10	−10	−6
−26	−41	−18	−27	−10	−20	−15	−1	−1	−2	−3·5	−8·5	−9	−9	−3	−11·5	−11·5	−6·5
−28	−54	−24	−26	−15	−24	−26	−2	−2	−3	−4·5	−9·5	−10	−10	−3	−13	−13	−7
−30	−74	−33	−41	−25	−42	−42	−4	−4	−5·5	−7·5	−14	−13	−13	−4	−16	−16	−8·5

* The first column under 6 being blank is omitted in printing.

Table I (continued).—Dark Wire.

Distances.	Deflections.																
	1.		2.		3.		4.		5.		6.*	7.			8.		
-32	-96	-43	-60	-35	-61	-60	-6·2	-6	-8	-11	-17·5	-16	-16	-5·5	-20	-20	-10
-34	-127	-56	-87	-54	-93	-81	-9	-9	-12	-15	-22·5	-23	-23	-8	-27	-27	-13
-36	-159	-71	-114	-72	-125	-102	-12·5	-12·5	-16	-19·5	-28	-30	-30·5	-11	-35	-35	-16
-38	-202	-88	-160	-100	-187	-142	-18·5	-18	-23	-27	-38	-41	-42	-14	-47	-48	-21
-40	-246	-106	-206	-128	-250	-184	-26·5	-25	-30·5	-35·5	-49	-52	-55·5	-18	-60	-62	-25
-42	-294	-128	-280	-170	-352	-254	-37·5	-35·5	-43	-49	-69	-73	-77	-22	-83	-86	-34
-44	-336	-150	-365	-226	-487	-340	-51·5	-49·5	-58·5	-67·5	-89	-94	-100	-30	-107	-110	-43
-46	-356	-166	-453	-282	-614	-442	-70	-68	-80	-89	-114	-121·5	-129·5	-41	-136	-143	-57
-48	-354	-169	-528	-340	-754	-554	-84·5	-82	-104	-110·5	-145	-161	-167·5	-58	-176	-183	-75
-50	-323	-160	-562	-386	-832	-622	-96	-93·5	-123	-128	-172	-192·5	-199	-81	-215	-220	-98
-52	-275	-134	-541	-375	-816	-608	-95·5	-93·5	-127	-131	-186	-214	-220	-101	-242	-247	-123
-54	-230	-102	-470	-332	-722	-548	-87·5	-84·5	-119	-122·5	-181	-211	-216	-112	-245	-246	-135
-56	-174	-78	-388	-272	-590	-454	-73·5	-70·5	-104	-106	-160	-196	-196	-110	-227	-226	-135
-58	-130	-57	-296	-204	-459	-352	-55·5	-54	-82	-84	-133	-165	-164	-95·5	-191	-191	-119
-60	-96	-44	-222	-157	-343	-268	-42	-41	-62	-64	-104	-130	-127	-75·5	-150	-150	-98
-62	-72	-32	-166	-119	-255	-206	-31·5	-31	-45·5	-46·5	-79	-99	-99	-58	-114	-114	-73
-64	-56	-26	-129	-91	-198	-160	-24	-23·5	-35	-36	-62	-73	-73	-45	-88	-88	-56
-66	-41	-20	-95	-70	-137	-118	-18	-17·5	-25·5	-25·5	-46	-54	-54	-32·5	-64	-64	-41
-68	-33	-16	-76	-55	-106	-91	-14	-13	-20	-20	-36	-42	-42	-25	-49	-49	-32
-70	-26	-12	-59	-41	-82	-68	-10	-9·5	-15	-15	-26	-32	-32	-18	-36	-36	-24
-80	-10	-4	-19	-16	-26	-22	-4	-3·5	-0·5	-0·5	-9	-10	-10	-5·5	-12·5	-12·5	-8
-90	-6	-3	-8	-6·5	-11	-8	-2	-1·5	-2·5	-2·5	-5	-5	-5	-2·5	-5	-5	-3
-100	-4	-2	-4	-3	-6	-3	-1	-0·5	-1·5	-1·5	-2	-2	-2	-1	-2	-2	-1·5

* The first column under 6 being blank is omitted in printing.

Table I.—Dark Wire.

Distances.	Deflections.															
	9.	10.	11.	12.			13.			14.		15.		16.		17.
100	Exactly the same as the second column under Heading 8.	Magnetising force used in 7, when reversed, gave the same deflections in opposite direction (directly after the reversal) as those in second column of 7.	Magnetising force used in 6, when reversed, gave the same deflections in opposite direction (directly after the reversal) as those in 6.	− 1	− 1	− 1	− 0·5	− 0·5	− 0·5	− 0	− 0·5	− 2	− 4	+ 1	− 1·5	1·5	0
90				− 1·5	− 1·5	− 1·5	− 1	− 1	− 1	− 0·5	− 1	− 5	− 10	+ 2	− 2·5	4	− 0·5
80				− 4	− 4·5	− 4·5	− 3	− 3·5	− 3	− 2	− 2·5	− 11	− 19	+ 5	− 6	8	− 2
70				− 14	− 14·5	− 14·5	−10	−11	−10	− 6	− 8	− 32	− 56·5	14	− 17	18	− 7
68				− 19	− 19	− 19	−13	−15	−13·5	− 8	−10	− 42	− 74	17	− 21	23	− 9·5
66				− 24	− 25	− 25	−16	−19	−17·5	−11	−13·5	− 54	− 95	22	− 26	29	−13
64				− 33·5	− 34	− 34	−22	−26	−24	−15	−18	− 74	−130	30	− 35	37	−18
62				− 42·5	− 43	− 45	−29	−34·5	−31	−20	−24	− 98	−171	39	− 46	49	−25
60				− 57	− 59	− 59	−39	−45	−42	−26	−31·5	−132	−229	52	− 60	67	−30
58				− 75	− 77	− 77	−50	−59·5	−53·5	−35	−42	−171	−300	70	− 81	92	−40
56				− 92	− 94	− 95	−60	−74·5	−68·5	−42	−51·5	−215	−382	97	−103	120	−50
54				−106	−107	−112	−71	−87·5	−82·5	−50	−61	−258	−465	127	−128	153	−59
52				−115	−115	−122	−80	−97	−92	−55·5	−68·5	−273	−520	156	−149	188	−66
50				−112	−114	−119	−76	−95·5	−91·5	−55·5	−69	−279	−536	181	−163	210	−71
48				− 99	− 99	−105	−73	−87	−85	−50	−63	−250	−501	179	−165	211	−69
46				− 76	− 78	− 86	−59	−71	−70	−40·5	−52	−195	−424	174	−156	193	−65
44				− 58	− 60	− 66	−46	−56	−55	−32	−41	−142	−341	160	−140	169	−57
42				− 44	− 46	− 50	−35	−42	−42	−24	−31	−104	−255	131	−119	138	−48
40				− 31	− 32	− 35	−25	−29·5	−29·5	−18	−23·5	− 72	−187	106	−100	109	−40
38				− 22	− 25	− 26	−18	−22	−22	−11·5	−17	− 53	−143	82	− 81	87	−32
36				− 15	− 18	− 18	−12	−15	−15	− 5·5	−12	− 36	−104	62	− 65	68	−25
34				− 10	− 13·5	− 14	− 9	−11	−11	− 4	− 9	− 25	− 76	47	− 51	54	−19
32				− 6	− 9·5	− 10	− 6	− 7	− 7	− 3	− 6	− 15	− 54	35	− 39	42	−15
30				− 5	− 7	− 7	− 4	− 5	− 5	− 2	− 4	− 11	− 39	26	− 30	32	−11
28				− 3	− 5	− 5	− 3	− 3	− 3	− 1·5	− 3	− 8	− 26	18	− 22	22	− 7
26				− 2·5	− 4·5	− 4	− 2·5	− 2·5	− 2·5	− 1	− 2	− 5	− 23	12	− 16	16	− 6
24				− 2	− 4	− 3	− 2	− 2	− 2	− 0·5	− 1·5	− 2	− 11	7	− 11	10	− 5
22				− 2	− 5	− 3	− 2	− 2	− 2	− 0·5	− 1	− 4	− 10	5	− 9	7	− 4·5

Table I (continued).—Dark Wire.

Distances.	Deflections.																
	9.	10.	11.	12.			13.			14.		15.		16.		17.	
20	Exactly the same as the second column under Heading 8.	Magnetising force used in 7, when reversed, gave the same deflections in opposite direction (directly after the reversal) as those in second column of 7.	Magnetising force used in 6, when reversed, gave the same deflections in opposite direction (directly after the reversal) as those in 6.	−2	−6	−3	−2	−2	−2	−0·5	−1	− 6	− 9	3	−8	5	−4
18				−3	−6	−3·5	−2·5	−2·5	−2·5	−0·5	−1	− 9	−10	2·5	−8	5	−4
16				−4	−6	−4	−3	−3	−3	−0·5	−1·5	−11	−13	2	−7	4	−4
14				−4	−6	−4	−1·5	−3	−3	−0·5	−2·5	−12	−15	2	−7·5	3	−3·5
12				−4	−5	−4	−2	−3	−3	0	−2	−14	−18	2	−7	3	−3
10				−4	−4·5	−3·5	−1·5	−3	−3	0	−2	−16	−19	3·5	−5·5	4	−2
8				−3·5	−3	−3	−1	−2·5	−2·5	0	−1·5	−17	−18	5	−4	5	−1
6				−3	−2	−2	−1	−2	−2	0	−1	−13	−16	4·5	−3	4·5	0
4				−1	−1	−1	−1	−1·5	−1·5	0	−1	− 8	−14	4	−2	4	+2
2				−0	−0·5	−0·5	−0·5	−1	−1	0	−0·5	− 4	−10	3·5	−0·5	2·5	2·5
0				0	0	0	0	0	0	0	0	0	− 6	3	+1	2	3
− 2				+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	0	+0·5	+ 2	− 3	1	2·5	+ 0·5	3
− 4				1	1	1	1	1	1	0	1	4	− 3	1	4	0	3
− 6				1·5	1·5	1·5	1	1	1	0	1	8	0	+ 0·5	4·5	− 0·5	2·5
− 8				2	1	2	1	1	1	0	0·5	11	+ 1	0	5	− 1	2
−10				1·5	1	1·5	0·5	0·5	0·5	0	0·5	8	2	−0·5	3·5	− 1	1
−12				1	1	1	0	0	0	0	0·5	+ 3	1	− 1	2	− 1	0
−14				1	0·5	1	0	0	0	0	0·5	− 1	0	− 2·5	2·5	− 1·5	− 0·5
−16				1	1	1	0	0	0	0	1	− 6	0	− 4	3	− 1·5	− 1
−18				1·5	0·5	1·5	0	0·5	0·5	0	1·5	−10	0	− 4·5	3	− 1·5	− 1
−20				2	1	2	0·5	0·5	0·5	0	1	−15	0	− 5	4	− 1·5	0
−22				3	2	3	1	1	1	0	1	−18	+ 2	− 5·5	7	− 3	0
−24				3·5	3	4·5	1·5	1·5	2	0	1·5	−20	4	− 6	9	− 5	0
−26				4·5	4	5·5	2	3	3	0	2	−19	8	− 9	15	− 6·5	+ 2
−28				6	5·5	6·5	3	4·5	4	+0·5	3	−18	12	−12	21	− 8	8
−30				7	9·5	9	5	6·5	6	2	4	−16	23	−18	29	−12	14

Table I (continued).—Dark Wire.

Distances.	Deflections.																
	9.	10.	11.	12.			13.			14.		15.		16.		17.	
−32	Exactly the same as the second column under Heading 8.	Magnetising force used in 7, when reversed, gave the same deflections in opposite direction (directly after the reversal) as those in second column of 7.	Magnetising force used in 6, when reversed, gave the same deflections in opposite direction (directly after the reversal) as those in 6.	9	12	11·5	7	9	8·5	3·5	5·5	−14	36	− 25	38	− 21	19
−34				13	15·5	15	9	12	11	4·5	7·5	−10	52	− 34	49	− 31	23
−36				16·5	19·5	19·5	11	15·5	14	5·5	10	− 4	70	− 46	62	− 42	29
−38				23	27	27	16	21·5	20	9	15	+12	104	− 65	77	− 61	36
−40				30	35	35	21	28	26	13	20·5	+26	144	− 86	93	− 83	42
−42				45	49	49	31	40	37	21	30	79	218	−116	111	−120	47
−44				61	65	65	42	52	49	30	40	136	311	−149	132	−162	56
−46				78	82	83	57	67	64	41	54·5	196	420	−178	149	−204	64
−48				97	101	102	72·5	83·5	80	52	66	273	510	−196	166	−238	70
−50				112	114	117	76	92	90	59	74	321	561	−197	170	−247	68
−52				116	116	122	83	94	93	60	73	326	550	−180	158	−228	66
−54				108	107	114	73	84	86	57	66	300	493	−147	136	−192	57
−56				95	94	100	65	71	73	47	58	257	410	−114	110	−156	49
−58				77	77	82	52	58	59	37	46	206	325	− 83	87	−116	39
−60				60	60	63	40	44	45	28	35	160	242	− 60	67	− 86	31
−62				45	45	47	30·5	33	33·5	21	26	118	182	− 43	50	− 63	23
−64				34	35	36	23	25	26	16	20	91	141	− 33	38	− 50	17
−66				25·5	26·5	26	17·5	18·5	19	12	15	68	104	− 25	28	− 37	13
−68				19	21	20·5	13	14·5	15·5	9	11	52	80	− 20	22	− 28	10
−70				14·5	14·5	15	10	11	11·5	6·5	8	39	60	− 15	18	− 20	7
−80				4·5	4·5	5	3	3·5	3·5	2·5	2·5	14	20	− 5	8	− 8	2
−90				1·5	1·5	1·5	1·5	1·5	1·5	1	1	6	11	− 2	3·5	− 4	0·5
−100				1	1	1	1	1	1	0	0·5	3	4	− 1	1·5	− 1·5	0

Table II.—Bright Wire.

Distances.	Deflections. 1.				2.*		3.				4.				5.			
100	3	1·5	1	− 1·5	0·5	0	1	1	0	− 0·5	1	1	0	− 1	1·5	1·5	− 1	− 1·5
90	6	3·5	3	− 3·5	1	0·5	2	2	0	− 1	2	2	− 0·5	− 2	3	3	− 2	− 3
80	14	8	6	− 8	3	1·5	4·5	4	0·5	− 3	5	5	− 2	− 5	7	7	− 5·5	− 7
70	40	29	24	− 29	8	4	14	12·5	1	−10·5	18	17	− 8	− 17	22·5	22·5	− 18·5	− 22·5
68	50	38	32	− 38	10	5	19	16	1	−14	24	23	−11	− 22	30	30	− 25	− 30
66	64	49	42	− 49	13	6·5	24	21·5	1·5	−18·5	31	30	−15	− 29	39·5	39·5	− 32·5	− 39
64	86	68	52	− 68	17	8·5	34	29	1·5	−25	42	40	−20	− 39	54	54	− 45	− 53
62	118	88	66	− 88	23	11	44	39	2	−33	56	52	−26	− 51	71	71	− 59·5	− 70
60	152	120	87	−120	30·5	15	60	51	2·5	−45	75	70	−35·5	− 69	94·5	95	− 79	− 94
58	196	159	112	−156	40	19·5	79	68	4	−58·5	98·5	93·5	−46·5	− 90·5	123	125	−103	−124
56	246	202	141	−200	51	25	96	82	5·5	−61·5	120·5	115	−56	−111	149	151	−123	−149
54	306	246	175	−246	59·5	31	108	93	9·5	−84	136	131·5	−62·5	−127	165	170	−139	−166
52	346	268	199	−266	66	36	119	102	14·5	−91	140	137	−61	−132	164·5	171	−142	−168
50	363	273	210	−272	66	38	113	97	19	−88	128	126·5	−61	−121	146	154	−125	−152
48	357	243	199	−242	60·5	37	97	82	23	−75·5	105	104	−35	−100	117	122	− 95	−121
46	336	211	171	−210	51·5	34·5	77	64	26	−60·5	79·5	77·5	−18	− 74	85	90	− 65	− 90
44	289	174	148	−174	41	29·5	59	46	26·5	−44·5	59	54·5	− 3	− 50·5	63	64	− 43	− 64
42	247	138	124	−138	31·5	25	52	30	25	−31	40	35	+ 6	− 33	41	42	− 21	− 42
40	196	102	93	−102	24·5	20	29	20	21·5	−22	27·5	23	+10·5	− 21	31	30	− 11	− 30
38	159	86	78	− 86	19	16	22	15	18	−16·5	21	17	+10	− 16	24	23	− 7·5	− 23
36	127	72	65	− 72	14·5	13	16	11	14·5	−12	15	12	10	− 11	18·5	17	− 4·5	− 17
34	103	64	56	− 64	11	10	12·5	9	11·5	− 9	12	10	8	− 8·5	15	14	− 4	− 14
32	81	56	49	− 56	9	8	9·5	7·5	9·5	− 7	9·5	8	6	− 6·5	12·5	11·5	− 3	− 11·5
30	70	48	42	− 48	7	6·5	7·5	6	7·5	− 6	7·5	6·5	5	− 6	9·5	9·5	− 2·5	− 9·5
28	60	40	36	− 40	5·5	5	6	5	5·5	− 5	6	5·5	4	− 5	7·5	8	− 2	− 8
26	54	36	31	− 36	5	4·5	5	4	5	− 4	5	5	3	− 4·5	7	7	− 2	− 7
24	48	31	26	− 31	4·5	4	4·5	3·5	4	− 3·5	4·5	4·5	2	− 4	6	6	− 2	− 6
22	46	29	23	− 29	4	4	4	3·5	3	− 3·5	4	4·5	1	− 4	5	5	− 2·5	− 5

* The first column under 2 being blank is omitted in printing.

Table II (continued).—Bright Wire.

Distances.	Deflections.																	
	1.				2.*		3.				4.				5.			
20	43	27	20	− 27	4	3·5	3	3	2·5	− 3	3	4·5	0	− 4	4·5	4·5	− 3	− 4·5
18	41	26	19	− 26	3·5	3	2	2	2	− 2	2·5	4	0	− 4	4	4	− 3	− 4
16	41	26	19	− 26	3·5	3	1·5	2	1	− 2	2	4	− 1	− 4	3·5	3·5	− 3·5	− 3·5
14	39	27	20	− 26	3	2·5	1·5	2·5	1	− 2·5	1·5	3·5	− 1·5	− 3·5	3·5	3·5	− 3·5	− 3·5
12	39	28	22	− 27	3	2	1	3	0·5	− 3	1·5	3	− 2	− 3	3	3	− 3·5	− 3
10	40	29	22	− 28	2·5	2	1	3·5	0·5	− 3·5	1	3	− 2	− 3	3	3	− 3	− 3
8	40	29	23	− 29	2·5	1·5	1	3·5	0·5	− 3·5	1	3	− 2·5	− 3	1·5	3	− 3	− 3
6	40	31	25	− 30	2·5	1·5	0·5	3·5	0·5	− 3·5	1	3·5	− 2·5	− 4	1·5	3	− 3·5	− 3
4	42	34	28	− 32	2·5	1·5	0·5	3·5	0	− 3·5	0·5	4	− 2	− 4	1·5	3	− 4	− 3
2	44	37	30	− 35	3	1·5	0·5	4	0	− 4	0·5	4	− 1 5	− 3·5	1	3	− 3·5	− 3
0	45	40	32	− 38	3	2	0	4	0	− 4	0	4	− 1	− 4	1	3	− 3	− 3
− 2	44	42	35	− 40	3	1	− 0·5	2	2	− 4	0	4	+ 2	− 4	0·5	2	− 1	− 2
− 4	42	45	38	− 43	3	2·5	− 0·5	4·5	3	− 4·5	− 0·5	4	4	− 4	0	1·0	0	− 1
− 6	40	44	37	− 42	2	2	− 1	3	3·5	− 3	− 1·5	2·5	6	− 2·5	− 0·5	0·5	+ 3	− 0·5
− 8	36	43	37	− 42	1·5	1·5	− 2	1·5	4·5	− 1·5	− 2	1·5	8	− 1·5	− 1	0	7	0
−10	30	37	32	− 37	0	0	− 2	0	4	0	− 2·5	0	8·5	0	− 2	− 0·5	8	+ 0·5
−12	24	31	28	− 32	− 1	− 1	− 3	− 1·5	3	+ 1·5	− 3·5	− 1·5	9	+ 1·5	− 3	− 1	9·5	1
−14	18	21	19	− 21	− 2	− 2	− 3	− 2·5	1	2	− 3·5	− 2·5	6	3	− 3·5	− 2	7·5	2
−16	+ 10	+ 11	+ 10	− 11	− 3·5	− 3	− 3	− 4	− 1·5	3·5	− 4	− 4	+ 3	4·5	− 4	− 2·5	5·5	3
−18	− 2	− 4	− 1	+ 4	− 4	− 4	− 3	− 4·5	− 3·5	3·5	− 3·5	− 4·5	− 1	5·5	− 4	− 3·5	+ 1·5	3·5
−20	− 16	− 18	− 13	+ 17	− 5	− 5	− 3	− 5	− 5·5	4	− 3	− 5	− 6	6·5	− 3·5	− 4·5	− 2	4·5
−22	− 38	− 33	− 24	33	− 5·5	− 5	− 3·5	− 6	− 7	5	− 3·5	− 5·5	− 7·5	7	− 5	− 5·5	− 2·5	5·5
−24	− 58	− 49	− 36	48	− 5·5	− 5·5	− 4	− 6·5	− 8·5	6	− 3·5	− 6	− 9	8	− 7	− 6·5	− 3	6·5
−26	− 79	− 59	− 47	59	− 6	− 5·5	− 5	− 7	− 8·5	6·5	− 4·5	− 6·5	− 8·5	8·5	− 8	− 8	− 1	8
−28	−111	− 70	− 58	70	− 6·5	− 6	− 6	− 7	− 9	7	− 6	− 7	− 8·5	8·5	− 9	− 9·5	0	9·5
−30	−140	− 78	− 62	78	− 8	− 7·5	− 7	− 7·5	− 9·5	7·5	− 8	− 8	− 8	9	− 9·5	− 1	+ 1	10

* The first column under 2 being blank is omitted in printing.

Table II (continued).—Bright Wire.

Distances.	Deflections.																	
	1.				2.*		3.				4.				5.			
−32...	−171	−87	−67	87	−9·5	−9	−10	−8	−10	8·5	−11	−9	−8	9·5	−11	−12	2	12
−34...	−189	−94	−71	94	−12	−10·5	−14	−9·5	−12	10	−15	−10·5	−8·5	10·5	−13·5	−15	3·5	15
−36...	−210	−104	−75	103	−15	−12·5	−18	−11·5	−14·5	12	−19	−12·5	−9	12	−17·5	−19	5	19
−38...	−227	−114	−85	114	−19	−16	−26	−16·5	−17·5	18	−26	−18	−8·5	18	−25	−27	10	26
−40...	−237	−125	−95	126	−24	−20	−34	−22·5	−21	23	−34	−25	−8	24	−32	−35	15	33·5
−42...	−259	−152	−112	150	−32	−24	−49	−33	−24	33	−48	−38	−2	37	−48	−50	26	49
−44...	−289	−186	−150	184	−42	−30	−65	−49	−26	46	−68	−57	+6	56	−68	−70	46	69
−46...	−319	−224	−186	225	−52	−35	−85·5	−67	−26	63	−90	−81	19	79·5	−95	−96	69	95
−48...	−359	−264	−223	265	−61	−38	−106	−87·5	−24	80	−120	−106	39	105	−126	−129	101	128
−50...	−389	−306	−251	306	−66·5	−39	−120	−101·5	−20	91·5	−137	−127	53	125	−152	−156	126	153
−52...	−373	−311	−250	312	−66	−36	−121·5	−105	−14·5	94·5	−143	−136	64·5	134	−166	−169	140	168
−54...	−340	−290	−233	292	−61	−31·5	−110	−99	−9	87·5	−134	−130	64	127	−160	−165	137	163
−56...	−287	−248	−195	245	−52	−26	−93·5	−85	−5·5	74	−114	−114	58	110·5	−142	−149	123	146
−58...	−237	−197	−162	196	−41·5	−20	−73·5	−67	−3·5	60·5	−91	−91	47·5	89	−114	−121	100	119
−60...	−182	−148	−124	150	−31	−15	−55	−56·5	−2	45	−70	−70	36	68	−86	−92	76	90
−62...	−138	−112	−96	111	−23·5	−11	−41	−38	−1·5	34	−51	−51·5	27	50	−63·5	−69	59	68
−64...	−109	−85	−77	85	−18	−8·5	−32	−29	−1·5	26	−40	−40	21	39	−48	−53	44	53
−66...	−83	−65	−59	65	−13·5	−6·5	−24	−21	−1·5	19	−30	−30	15	28	−36	−39	32·5	39
−68...	−65	−50	−47	49	−10	−5	−19	−16	−1	14·5	−24	−24	11	22	−29	−30	24	30
−70...	−43	−38	−35	38	−8	−4	−14	−12·5	−1	10·5	−18	−18	8	17	−22·5	−22·5	18·5	22·5
−80...	−15	−12	−10	12	−3	−1·5	−4	−4	−0·5	3	−5	−5	2	5	−7	−7·5	5 5	7·5
−90...	−8	−6	−5	6	−1	−0·5	−2	−2	0	1	−2	−2	0·5	2	−3	−3	2	3
−100...	−4	−3	−2	3	−0·5	−0	−1	−1	0	0·5	−1	−1	0	1	−1·5	−·5	1	1·5

* The first column under 2 being blank is omitted in printing.

Table II.—Bright Wire.

Distances.	Deflections.													
	6.				7.*			8.				9.*		
100	2	2	− 1·5	− 2	2	− 2	All the deflections the same as those in the second column, 7, with their signs changed.	2·5	2·5	All the deflections the same as those in the last column, with their signs changed.	All the deflections the same as those in the last column, with their signs changed.	2·5	− 2·5	All the deflections the same as those in the last column, with their signs changed.
90	4	4·5	− 3·5	− 4·5	5	− 5		5·5	5·5			6	− 6	
80	8	9	− 7	− 9	11·5	− 11·5		14	14			15	−15	
70	28	29	− 26	− 28·5	37·5	− 37·5		43·5	44			50	−50	
68	37	38	− 36	− 36	50	− 49·5		59	59			66	All the deflections the same as those in the last column, with their signs changed.	
66	48	49·5	− 47	− 46	65	− 64·5		76	76·5			86		
64	66	68	− 66	− 67	90	− 89		102	103			117		
62	88	91	− 88	− 90	119	−117		138	141·5			159		
60	115	120	−116	−117	155	−155		181	186·5			208		
58	151	156	−151	−153	199	−199		227	240			265		
56	180	187	−178	−184	235	−235		265	278			307		
54	196	205	−196	−202	258	−257		276	300			327		
52	192	202	−195	−199	251	−249		264	287			307		
50	163	175	−171	−174	215	−214		224	244			261		
48	126	136	−133	−135	165	−164		174	189			202		
46	91	100	− 95	−100	120	−120		125	138			146		
44	65	70	− 67	− 70	86	− 86		89	98·5			104		
42	43	47	− 45	− 48	60·5	− 60·5		63	70			76		
40	31	35	− 31	− 35	43	− 43		44	49			56		
38	24	27	− 24	− 27	33	− 33		35	39			43		
36	17·5	20	− 18	− 20	24·5	− 24·5		27	29			32·5		
34	14	16	− 14	− 16	19	− 19		22	23			26		
32	11	13	− 11·5	− 13	15	− 15		17	18			20		
30	9	11	− 9	− 11	12·5	− 12·5		14	15			16		
28	7	9·5	− 8	− 9·5	10	− 10		11	12			14		
26	6·5	8·5	− 6·5	− 8·5	9	− 9		10	11			12		
24	5·5	7·5	− 5·5	− 7·5	8·5	− 8·5		9	9·5			10·5		
22	4·5	7	− 5	− 7	8	− 8		8·5	8			9·5		

* The first columns under 7 and 9 being blank are omitted in printing.

Table II (continued).—Bright Wire.

Distances.	Deflections.													
	6.				7.*			8.				9.*		
20	4	5·5	− 5	− 5·5	7·5	− 7·5	All the deflections the same as those in the second column, 7, with their signs changed.	8	7·5	All the deflections the same as those in the last column, with their signs changed.	All the deflections the same as those in the last column, with their signs changed.	9	All the deflections the same as those in the last column, with their signs changed.	All the deflections the same as those in the last column, with their signs changed.
18	3·5	4·5	− 4	− 4·5	7	− 7		7	5·5			8·5		
16	3	4	− 4·5	− 4	6	− 6		6·5	5			8·5		
14	3	3·5	− 4	− 3·5	5·5	− 5·5		6	4·5			8		
12	2·5	2·5	− 3·5	− 2·5	5	− 5		6	4·5			8		
10	2·5	3	− 3	− 3	4·5	− 4·5		5·5	4			7		
8	2	3	− 3	− 3	4	− 4		5	3·5			6		
6	2	3·5	− 3·5	− 3·5	4	− 4		4	3			6		
4	2	3·5	− 3·5	− 3·5	4·5	− 4·5		4	3			5·5		
2	1·5	3·5	− 3·5	− 3	4	− 4		3	2			5		
0	1	3	− 4	− 3	4	− 4		2	2			4		
− 2	0·5	3	− 3	− 1·5	2·5	− 2·5		1	1·5			3		
− 4	0	2	− 2	0	1·5	− 1·5		0	0·5			2		
− 6	− 0·5	1·5	− 0·5	0	0·5	0·5		0	0			1		
− 8	− 0·5	+ 0·5	+ 1	+ 0·5	0	0		− 0·5	− 0·5			0		
−10	− 1	− 0·5	1·5	1	− 1	− 1		− 0·5	− 1			− 0·5		
−12	− 2	− 1·5	2	2	− 2	− 2		− 1	− 1·5			− 1		
−14	− 2·5	− 2	2·5	2·5	− 3	− 3		− 1	− 2·5			− 1·5		
−16	− 3	− 3	3	3	− 3·5	− 3·5		− 1·5	− 3			− 1·5		
−18	− 3·5	− 4	4	3·5	− 5	− 5		− 2·5	− 4·5			− 3·5		
−20	− 4·5	− 5	4·5	4·5	− 6	− 6		− 4	− 5·5			− 5		
−22	− 5·5	− 6	5·5	6	− 8	− 8		− 6·5	− 8			− 8		
−24	− 7	− 7·5	6	7	−10	−10		− 9	−10·5			−11		
−26	− 8·5	− 9·5	7·5	8·5	−12	−12		−12	−12·5			−13		
−28	−10	−11	9	10	−13·5	−13·5		−14	−14·5			−15		
−30	−11·5	−13·5	10·5	11	−16	−16		−16	−16			−18		

* The first columns under 7 and 9 being blank are omitted in printing.

Table II (continued).—Bright Wire.

Distances.	Deflections.													
	6.				7.*			8.				9.*		
− 32... ...	− 13	− 14·5	12	12·5	− 18	− 18	All the deflections the same as those in the second column, 7, with their signs changed.	− 18	− 19	All the deflections the same as those in the last column, with their signs changed.	All the deflections the same as those in the last column, with their signs changed.	− 21	All the deflections the same as those in the last column, with their signs changed.	All the deflections the same as those in the last column, with their signs changed.
− 34... ...	− 16·5	− 18·5	15·5	16	− 22	− 22		− 23	− 24			− 26		
− 36... ...	− 20	− 22	19	20	− 27	− 27		− 28	− 29			− 31		
− 38... ...	− 28	− 29	25·5	27·5	− 35	− 34		− 39	− 39			− 42		
− 40... ...	− 36	− 37	32	35	− 45	− 45		− 50	− 49·5			− 54		
− 42... ...	− 53	− 53	48	51	− 62·5	− 62·5		− 70	− 69			− 76		
− 44... ...	− 74	− 75	72	73	− 88·5	− 88·5		− 97	− 96			−106		
− 46... ...	−105	−106	102	104	−122	−122		−134	−134·5			−146		
− 48... ...	−140	−141	138	138	−167	−166		−193	−197			−206		
− 50... ...	−173	−175	172	172	−209	−208		−240	−246			−264		
− 52... ...	−193	−198	191	196	−245	−243		−279	−288			−317		
− 54... ...	−191	−197	192	195	−252	−251		−286	−292			−336		
− 56... ...	−174	−182	176	180	−236	−236		−264	−276			−317		
− 58	−142·5	−151	142	149	−200	−199		−221	−233			−272		
− 60... ...	−110	−115	110	114	−155	−154		−172	−185			−212		
− 62... ...	− 82	− 86	82	85	−118	−117		−129	−141			−159		
− 64... ...	− 63	− 67	63	66	− 89	− 89		− 96	−103			−118		
− 66... ...	− 46	− 49	46	48	− 68	− 66		− 74	− 78			− 88		
− 68... ...	− 36	− 38	36	38	− 47	− 47		− 57	− 59			− 67		
− 70... ...	− 27	− 29	26	28·5	− 37·5	− 37·5		− 43·5	− 44			− 50		
− 80... ...	− 7·5	− 9	7	9	− 11·5	− 11·5		− 14	− 14			− 15		
− 90... ...	− 3·5	− 4·5	3·5	4·5	− 5	− 5		− 5·5	− 5·5			− 6		
−100... ...	− 1·5	− 2	1·5	2	− 2	− 2		− 2·5	− 2·5			− 2·5		

* The first columns under 7 and 9 being blank are omitted in printing.

Table III.—Steel Pianoforte Wire.

Distances.	Deflections.															
	1.		2.		3.		4.		5.		6.		7.*		8.*	
100	0	0	0·5	0·5	2	2	0·5	0·5	1	1	1·5	1·5	2	1	2·5	1·5
90	0·5	0·5	2	2	5	5	1	1	2	2	3	3	4	2·5	5	3
80	1	1	5	5	12	12	2	2	5	5	8	8	10	5·5	12	8
70	2·5	2·5	18	19	38	39	4·5	4·5	15	15	24	24	30	18	36	24
68	3	3	25	25	52	53	6·5	6·5	20	20	30	30	40	25	47	32
66	4	4	32	33	67	69	8·5	8·5	27	27	39	39	51	32·5	60	41
64	5	5	45	45	92	99	11	11	37	37	54	54	71	45	82	57
62	6·5	6·5	58	59	118	123	14	14·5	48	48	71	72	93	58	110	74
60	10	10·5	75	78	157	166	18·5	18·5	62	63	84	85	129	74·5	142	98
58	13	13·5	97	102	209	215	25	25·5	81	83·5	120	122	154	91	185	119
56	17·5	18	123	128	255	265	33	33·5	101	105	143	148	183	101·5	222	135
54	22	22	143	152	302	314	42	42·5	119	125·5	163	171	208	102	250	135
52	27·5	28	156	166	332	348	53	53·5	132	141	178	183	217	92	254	121
50	30·5	30·5	159	172	342	371	61·5	62	137	147	178	183	208	75·5	242	99
48	31	31	143	157	327	357	63	65	132	140	161	167	189	60	217	79
46	29	30	127	134	286	311	59	62	112	122	132	140	157	47	173	58
44	25·5	26	106	111	236	262	51	55	89	100	103	111	124	36·5	134	46
42	21·5	21·5	82	86	180	203	41	43·5	68	78	77	85	94	28·5	103	36
40	19	19	59	63	141	162	30·5	35	50	57	55·5	64	71	23	73	26
38	15·5	16	46	50	111	127	24·5	27·5	39	44	43	50	54	18	64	21
36	12·5	13	34	37	83	95	18	20	27	32	31	37	40	13·5	48	17
34	10·5	11	27	30	65	75	14	16	22	25·5	24	29	31	10	33	15
32	8·5	9·5	22	24	49	57	10	11·5	16·5	19·5	18	22	25	8	24	13
30	8	9	17	20	39	46	7·5	9	12	16	14	18	20	7	16	12
28	7·5	7·5	14	16	29	36	6·5	7	9·5	10·5	11	15	16	5·5	14	10
26	7·5	7·5	12	14	24	28	5·5	6	7·5	9	9	13	14	4·5	11	8
24	7·5	7·5	11	13	19	21	4·5	4·5	6·5	7·5	7·5	11	12	4·5	9	7
22	7	7	9	11	15	16	4	4	5·5	6	6·5	10	11	4	8·5	6·5

* The first columns under 7 and 8 being blank are omitted in printing.

Table III (continued).—Steel Pianoforte Wire.

Distances.	Deflections.															
	1.		2.		3.		4.		5.		6.		7.*		8.*	
20	6	6·5	7	9	12	12	4	4	4	5	6	9	9	4	8	6
18	6	6·5	6	7	8	8	3	3	3·5	4·5	5·5	8·5	8	4	7·5	5·5
16	5·5	6	5	7	3	3	2	2	3·5	4	5	8	8	4	7	5
14	5·5	6	4	6	0	− 1	1·5	1·5	3	3·5	5	7·5	7	4	6·5	4·5
12	5	5·5	3	5	− 4	− 5	1	1	2·5	3	4·5	7	6	4	6	4
10	4·5	4·5	2·5	3·5	− 5	− 7	0	0	2	2·5	4	6·5	5	4	5·5	3·5
8	3	3	2	2·5	− 6	− 8	− 0·5	− 0·5	2	2	4	6	5	3	5	3
6	1·5	1·5	1	2	− 7	− 9	− 1	− 1	2	1·5	3·5	5	4	3	4	2
4	0	0	0	0	−10	−11	− 1	− 1	1·5	1	3	4	3·5	2	3	1
2	−0·5	−0·5	0	0	− 6	− 8	− 1	− 1	1	0	2	3·5	3	2	2	0·5
0	−1	−1	0	0	− 4	− 6	− 1	− 1	0	0	1	3	3	2	0	0
− 2	−2	−2	0	0	− 2	− 4	− 0·5	− 0·5	− 0·5	0	0	1·5	1	1	0	−1
− 4	−2·5	−2·5	1	1	0	− 5	− 0·5	− 0·5	− 1	0	0	0	0	0	− 0·5	−2
− 6	−3	−3	0	0	− 1	− 5	− 0·5	− 0·5	− 1·5	−0·5	− 0·5	−0·5	−1	−1	− 1	−2·5
− 8	−3·5	−3·5	− 1	−1	− 2	− 4	− 0·5	− 0·5	− 2	−1	− 1	−1	−2	−1	− 2	−3
−10	−3·5	−3·5	− 0·5	−0·5	− 1	− 4	− 0·5	− 0·5	− 2·5	−2·5	− 1·5	−1·5	−2·5	−1	− 2	−3·5
−12	−3·5	−3·5	0	0	− 1	− 3	− 0·5	− 0·5	− 3	−3	− 3	−3	−3	−1	− 3	−3·5
−14	−3·5	−3·5	− 0·5	−0·5	− 2	− 4	− 0·5	− 0·5	− 3	−3	− 3	−3	−3	−1	− 4·5	−4
−16	−3·5	−3·5	− 1	−1	− 2	− 5	− 0·5	− 0·5	− 3	−3	− 3	−3	−3	−1·5	− 6	−5
−18	−3·5	−3·5	− 3	−3	− 3	− 7	− 1	− 1	− 3·5	−4	− 4	−4	−3·5	−2	− 7	−5·5
−20	−3·5	−3·5	− 5	−5	− 4	−10	− 1·5	− 1·5	− 4	−5	− 5	−5	−5	−2	− 8	−6
−22	−3	−3	− 9	− 9	− 9	−18	− 2·5	− 2·5	− 5	−6	− 5·5	−5·5	−6	−2·5	− 9	−6·5
−24	−3	−3	−13	−13	−14	−27	− 4	− 4	− 6	−7	− 7	−7	−7	−3·5	−10	−7
−26	−4	−4	−18	−18	−23	−36	− 5·5	− 5·5	− 7·5	−8·5	− 9	−9·5	−9	−4	−13	−7·5
−28	−5	−5	−23	−23	−33	−46	− 7·5	− 7·5	− 9	−10	−11	−12	−13	−4	−16	−8
−30	−4	−4	−27	−29	−45	−59	−10	−10·5	−13	−14	−15	−16	−17	−5·5	−21	−9·5

* The first columns under 7 and 8 being blank are omitted in printing.

Table III (continued).—Steel Pianoforte Wire.

Distances.	Deflections.															
	1.		2.		3.		4.		5.		6.		7.*		8.*	
−32......	−4·5	−4·5	−31·5	−34	−59	−73	−13·5	−14	−17	−18	−20	−21	−22	−7	−27	−11
−34......	−6	−6	−37	−41	−76	−90	−17	−18	−23	−24	−28	−30	−28	−10	−36	−14
−36......	−7·5	−7·5	−44	−48	−95	−108	−21·5	−23	−30	−31	−35	−37	−38	−13	−45	−17
−38......	−10	−10	−53	−59	−120	−134	−27	−29	−42	−42	−47	−50	−48	−16	−60	−22
−40......	−13·5	−13·5	−64	−72	−146	−163	−33	−35	−54	−54	−60	−64	−61	−19	−80	−26
−42......	−18	−19	−81	−90	−181	−195	−41	−43	−71	−74	−81	−86	−88	−23	−105	−35
−44......	−24	−25	−105	−114	−219	−242	−50	−52	−91	−96	−103	−108	−119	−32	−140	−45
−46......	−31	−32	−130	−140	−248	−287	−56	−58	−112	−119	−128	−132	−153	−43·5	−178	−60
−48......	−36	−37	−153	−164	−314	−329	−61	−62	−129	−138	−163	−167	−191	−59	−215	−78
−50......	−38	−39	−162	−174	−330	−346	−59	−60	−136	−145	−178	−183	−217	−81	−242	−100
−52......	−36	−37	−159	−172	−320	−337	−50·5	−52	−131	−140	−179	−184	−228	−101	−253	−125
−54......	−28	−29	−146	−156	−291	−307	−40·5	−42	−118	−125	−168	−175	−216	−112	−242	−137
−56......	−23	−24	−128	−136	−250	−262	−31	−32·5	−101	−106	−147	−153	−193	−110	−216	−137
−58......	−17	−18	−107	−111	−207	−217	−24	−25	−83	−87	−121	−127	−158	−95·5	−180	−121
−60......	−15	−15	−82	−84	−159	−167	−17·5	−18	−64	−66	−95	−100	−121	−75·5	−140	−99
−62......	−9·5	−9·5	−63	−65	−123	−127	−14	−14·5	−48	−49	−72	−77	−90	−58	−107	−74
−64......	−7·5	−7·5	−48	−50	−95	−99	−11	−11·5	−37	−38	−55	−60	−66	−45	−79	−57
−66......	−6	−6	−35	−37	−68	−72	−8·5	−8·5	−27	−27	−39	−44	−50	−32·5	−58	−41
−68......	−4·5	−4·5	−27	−28	−53	−55	−6·5	−6·5	−21	−21	−31	−35	−37	−25	−45	−32
−70......	−3	−3	−20	−20	−38	−39	−4·5	−4·5	−15	−15	−24	−25	−30	−18	−35	−24
−80......	−1	−1	−6	−6	−12	−12	−2	−2	−5	−5	−8	−8	−10	−5·5	−12	−8
−90......	−0·5	−0·5	−3	−3	−5	−5	−1	−1	−2	−2	−3	−3	−4	−2·5	−5	−3
−100......	0	0	−1	−1	−2	−2	−0·5	−0·5	−1	−1	−1·5	−1·5	−2	−1	−2·5	−1·5

* The first columns under 7 and 8 being blank are omitted in printing.

Table IV.

Glass-hard-tempered Steel Wire.

Distances.	Deflections. 1.	2.	3.		4.	5.		6.	
100....	0·5	0	0·5	0	1	1·5	0	2	0
90....	1·5	0·5	1·5	0·5	2·5	3·5	0·5	4·5	0·5
80....	3	1·5	3	1	5·5	7	1·5	9	1·5
70....	9·5	4	9·5	2	17	22·5	3·5	27	3·5
68....	13	5·5	12	3	22	30	4	36	4
66....	18	7	15·5	3·5	28	39·5	4·5	47	4·5
64....	24	10	20·5	4·5	37	52·5	5·5	63	5·5
62....	31	13·5	25·5	5	49	71	6·5	82	6·5
60....	40	16	33·5	6·5	64	93	8	105	8
58....	49·5	21	41	8	79	115·5	10	131	10
56....	55	25	48	10	90	130	13	146	13
54....	56	25	51	12·5	96	136	17	152	16·5
52....	50	26	53·5	17·5	95	132	22	145	21
50....	40	26·5	55	24	91·5	122	29·5	135	28·5
48....	33	28	60	32	92·5	117·5	39	125	39
46....	25·5	30·5	68·5	42·5	99·5	120·5	52·5	126	50
44....	22	36·5	82	55·5	111	129	69	136	66
42....	24	43·5	97	70	125	142	85	148	84
40....	34	50	107·5	82	134	148·5	96·5	154	98·5
38....	52	53·5	108	85	132	142·5	98	146	102
36....	70	51	98·5	80	117	122	89·5	129	94·5
34....	80	45	80·5	67·5	94	97	74	106	79·5
32....	77	35	61·5	53	72	73·5	57	79	61
30....	67	27·5	45·5	39	54	53	42	59	45·5
28....	53	19·5	33	28	38·5	38·5	31	44	33·5
26....	41	14·5	23·5	21	28·5	28	22·5	33	24·5
24....	31·5	10	17	15	21	20·5	16	26	18
22....	25	7·5	13	11	16	18·5	12·5	20·5	14·5
20....	19	5	11	9	13	13·5	9·5	17·5	11
18....	15	4·5	9·5	7·5	11·5	11·5	9	15·5	9
16....	11	3·5	8	6	9·5	9·5	7	13	7·5
14....	8	3	7	5	8	8·5	6	11	6
12....	5·5	2·5	6	4	6·5	7·5	5	9·5	5
10....	4	2	5	3·5	5·5	6·5	4·5	8·5	4·5
8....	3·5	1·5	4·5	3	4·5	6	4	8	4
6....	3	1	4	2	3·5	5·5	3	8	3
4....	3	1	3	1·5	3	5	2	7	2
2....	3	0	2·5	1	2·5	4	1·5	5·5	1·5
0 ...	2	0	2	0·5	2	4	1	5	1

Table IV (continued).

Glass-hard-tempered Steel Wire.

Distances.	Deflections.								
	1.	2.	3.		4.	5.		6.	
− 2...	1	0	0·5	0	1	2	0	3	0
− 4...	2	0	0	− 0·5	0	1	− 0·5	1	− 0·5
− 6...	2	− 0·5	− 0·5	− 1	− 0·5	− 0·5	− 1	0	− 0·5
− 8...	2	− 1	− 1·5	− 1·5	− 1	− 1	− 1·5	− 1	− 1
−10...	1·5	− 1·5	− 2	− 2	− 2	− 2	− 2·5	− 1·5	− 2
−12...	1	− 2	− 2·5	− 2·5	− 3	− 3	− 3·5	− 2·5	− 2·5
−14...	0	− 2·5	− 4	− 3	− 4·5	− 4·5	− 4·5	− 4	− 3·5
−16...	− 1	− 2·5	− 5·5	− 4	− 6	− 6	− 5·5	− 6	− 5
−18...	− 2·5	− 3·5	− 7·5	− 6	− 9	− 9	− 7·5	− 9	− 7
−20...	− 4	− 5	−10	− 8	−12	−12·5	−10	−12	− 9
−22...	− 6	− 7·5	−14·5	−12	−17	−18	−14·5	−17	−13
−24...	− 8	−10·5	−19·5	−16·5	−23	−24	−19	−23	−17·5
−26...	−12·5	−15	−27	−23	−31·5	−33	−26	−33	−24
−28...	−17·5	−20	−35	−30	−40·5	−44	−34	−43·5	−32
−30...	−25	−27·5	−47·5	−40·5	−56	−59	−44	−59·5	−44
−32...	−34·5	−35·5	−63	−54	−76	−80·5	−59	−80	−58
−34...	−50·5	−45	−81	−68	−97	−104·5	−75	−105	−75
−36...	−66	−50	−98·5	−90	−118	−126	−91	−134	−93
−38...	−77·5	−53	−108	−85	−132·5	−145·5	−99	−154	−104
−40...	−81	−51·5	−107·5	−82	−135	−154	−97	−160	−102
−42...	−77	−44·5	−96·5	−70	−125	−145	−86·5	−153	−89·5
−44...	−70	−37	−82·5	−55·5	−110	−131	−68	−139	−70
−46...	−65	−31	−68	−42·5	−98	−117	−51	−132	−54
−48...	−61	−28·5	−59	−32	−90	−118	−37	−132	−40
−50...	−60	−26·5	−54·5	−24	−90·5	−124	−29·5	−141	−29
−52...	−63	−26	−53	−17·5	−92	−131	−22	−154	−22
−54...	−64	−25	−51	−12·5	−94	−134	−17	−160	−16·5
−56...	−60	−25	−48	−10	−89	−129	−13	−153	−12·5
−58...	−57	−21	−41	− 8	−80	−115	−10	−128	− 9·5
−60...	−45	−16	−33	− 6·5	−65	−92	− 8	−104	− 7·5
−62...	−33	−13	−25	− 5	−50	−70	− 6·5	−88	− 6·5
−64...	−23	−10	−20	− 4·5	−39	−52·5	− 5·5	−63	− 5·5
−66...	−17	− 7	−15	− 3·5	−29	−38·5	− 4·5	−47	− 4·5
−68...	−12	− 5·5	−12	− 3	−22	−30	− 4	−36	− 4
−70...	− 9·5	− 4	− 9·5	− 2	−17	−22·5	− 3·5	−27	− 3·5
−80...	− 3	− 1·5	− 3	− 1	− 5·5	− 7	− 1·5	− 9	− 1·5
−90...	− 1·5	− 0·5	− 1·5	− 0·5	− 2·5	− 3·5	− 0·5	− 4·5	− 0·5
−100...	− 0·5	0	− 0·5	0	− 1	− 1·5	0	− 2	0

Table V.—Cast-Iron Bar.

Distances.	Deflections.																
	1.	2.		3.	4.		5.	6.		7.	8.	9.	10.	11.	12.	13.	14.
100																	
90																	
80																	
70																	
60	8·5	33	17·5	73	88	46	96	105	50	..	..	..	..	51	35	− 26	− 88
58	9·5	37	20	83	100	52	110	120	56	..	..	..	..	58	40	− 30	−100
56	10·5	42	23	95	116	60	126	136	65	..	..	..	..	67	46	− 34	−116
54	12	47·5	26	109	133	70	144	157	75	..	..	..	..	78	53	− 38	−133
52	14	54·5	30	125	154	80	165	180	86	..	..	..	..	89	61	− 44	−154
50	16	63	34	143	176	92	190	208	99	..	..	..	..	102	71	− 51	−175
48	18·5	73	39	165	203	100	220	240	108	..	..	..	..	112	81	− 59	−202
46	21	84	46	191	233	122	251	276	130	..	..	..	..	136	93	− 67	−231
44	24·5	96	52	214	264	135	286	314	154	..	..	..	..	160	105	− 77	−262
42	28	109	60	248	303	161	328	355	171	..	..	..	..	178	121	− 88	−300
40	31·5	124	68	279	341	183	367	401	194	..	..	..	..	203	138	− 99	−336
38	35	138	77	310	380	205	410	446	216	..	..	..	..	226	154	−111	−375
36	38·5	154	86	343	418	228	450	490	240	..	..	..	..	251	171	−122	−412
34	41·5	169	95	374	453	250	488	529	263	..	..	..	..	274	188	−134	−447
32	44	183	105	400	484	269	519	630	282	..	..	..	..	294	203	−143	−478
30	47	193	114	419	503	285	541	580	310	..	..	..	..	313	215	−152	−495
28	49	202	120	430	512	298	550	590	322	600	690	742	760	323	224	−158	−508
26	49	207	124	432	510	304	546	584	328	..	..	..	..	328	229	−161	−505
24	49	205	127	424	498	300	529	573	318	..	..	..	..	325	227	−159	−494
22	47	201	125	405	470	292	500	531	308	..	..	..	..	314	222	−156	−468

Table V (continued).—Cast-Iron Bar.

Distances.	Deflections.																
	1.	2.		3.	4.		5.	6.		7.	8.	9.	10.	11.	12.	13.	14.
20	45	191	123	380	438	278	463	488	293	..	..	..	..	297	213	−148	−436
18	42	180	118	348	397	259	419	440	272	..	..	..	..	274	199	−140	−396
16	38·5	166	111	312	352	236	369	388	246	..	..	..	..	247	182	−128	−352
14	35	148	103	273	305	211	320	333	219	..	..	..	..	219	165	−116	−307
12	31	128	91	232	257	182	267	280	189	..	..	..	..	189	141	−102	−259
10	26	111	78	193	208	152	217	227	158	..	..	..	..	158	118	− 97	−215
8	22	87	63	151	165	122	170	177	124	..	..	..	..	124	88	− 72	−165
6	18	67	50	114	124	93	126	128	94	..	..	..	..	94	65	− 57	−125
4	13	42	34	74	79	61	83	85	62	..	..	..	..	62	43	− 42	− 79
2	7	21	16	36	37	30	40	42	30	..	..	..	..	30	19	− 20	− 39
0	2	1	0	0	0	0	0	0	1	..	..	..	..	1	0	0	0
− 2	− 7	− 20	− 16	− 36	− 37	− 30	..	..	− 30								
− 4	−13	− 40	− 34	− 74	− 79	− 61	..	..	− 62								
− 6	−18	− 64	− 50	−114	−124	− 93	..	..	− 94								
− 8	−22	− 86	− 63	−151	−165	−122	..	..	−124								
−10	−26	−107	− 78	−193	−208	−152	..	..	−158								
−12	−31	−126	− 91	−231	−257	−182	..	..	−189								
−14	−35	−146	−103	−272	−305	−210	..	..	−219								
−16	−38	−162	−111	−310	−352	−237	..	..	−246								
−18	−42·5	−178	−118	−348	−396	−259	..	..	−272								
−20	−45	−189	−123	−380	−436	−278	..	..	−293								

Table V (continued).—Cast-Iron Bar.

Distances.	Deflections.																
	1.	2.		3.	4.		5.	6.		7.	8.	9.	10.	11.	12.	13.	14.
−22	−47·5	−198	−125	−404	−470	−292	..	..	−308								
−24	−50	−203	−127	−425	−495	−299	..	..	−318								
−26	−51	−206	−124	−422	−502	−304	..	..	−328								
−28	−51	−206	−120	−428	−510	−298	..	..	−323								
−30	−47	−196	−115	−418	−499	−286	..	..	−310								
−32	−44·5	−188	−106	−400	−482	−269	..	..	−285								
−34	−42	−170	− 95	−375	−452	−250	..	..	−264								
−36	−38·5	−156	− 86	−345	−417	−228	..	..	−241								
−38	−35	−140	− 77	−312	−380	−205	..	..	−216								
−40	−31·5	−138	− 68	−280	−340	−183	..	..	−196								
−42	−28	−110	− 60	−250	−302	−161	..	..	−172								
−44	−24·5	− 98	− 52	−215	−263	−142	..	..	−156								
−46	−21	− 86	− 46	−191	−232	−122	..	..	−132								
−48	−19	− 74	− 39	−165	−203	−106	..	..	−109								
−50	−16	− 63	− 34	−143	−176	− 92	..	..	− 99								
−52	−14	− 54	− 30	−125	−153	− 80	..	..	− 86								
−54	−12	− 48	− 26	−109	−132	− 70	..	..	− 75								
−56	−10·5	− 41	− 23	− 95	−115	− 60	..	..	− 65								
−58	− 9·5	− 36	− 20	− 83	−100	− 52	..	..	− 56								
−60	− 8·5	− 33	− 17·5	− 73	− 88	− 46	..	..	− 50								
−70																	
−80																	
−90																	
−100																	

Table VI.—Steel Bar, Hard-tempered.

Distances.	Deflections.								
	1.	2.	3.	4.	5.	6.	7.	8.	9.
100									
90									
80									
70									
60	108	...	...	...	103	90	6	− 62	− 70
58	123	...	...	...	117	104	8	− 71	− 78
56	141	...	...	...	135	120	10	− 80	− 90
54	160	...	...	...	156	138	12	− 91	−102
52	185	...	...	...	179	160	14	−102	−116
50	213	...	...	...	207	182	16	−118	−133
48	245	...	...	...	237	208	20	−133	−153
46	280	...	...	...	274	242	24	−153	−175
44	317	...	...	...	314	276	28	−173	−197
42	363	...	...	...	358	318	32	−201	−227
40	408	...	...	...	400	356	37	−219	−254
38	455	...	...	...	444	396	44	−243	−282
36	500	...	...	...	487	438	50	−266	−310
34	540	...	...	...	527	474	58	−291	−337
32	577	...	...	...	559	506	65	−313	−360
30	600	...	...	...	579	529	70	−326	−382
28	612	780	850	870	591	540	76	−336	−394
26	610	...	...	...	577	541	79	−343	−400
24	593	...	...	...	569	520	83	−340	−394
22	564	...	...	...	541	505	81	−334	−385
20	525	...	...	...	506	473	78	−320	−372
18	478	...	...	...	458	432	74	−300	−348
16	425	...	...	...	410	389	66	−278	−322
14	371	...	...	...	354	337	58	−256	−294
12	315	...	...	...	296	284	47	−226	−262
10	262	...	...	...	246	237	36	−196	−225
8	206	...	...	...	196	189	23	−166	−192
6	152	...	...	...	144	138	+10	−138	−157
4	98	...	...	...	90	83	− 5	−108	−122
2	48	...	...	...	43	39	−15	− 75	− 83
0	0	...	...	...	0	0	−30	− 42	− 44
− 2									
− 4									
− 6									
− 8									
− 10									
− 12									
− 14									
− 16									
− 18									
− 20									
− 22									
− 24									
− 26									
− 28									
− 30									
− 32									
− 34									
− 36									
− 38									
− 40									
− 42									
− 44									
− 46									
− 48									
− 50									
− 52									
− 54									
− 56									
− 58									
− 60									
− 70									
− 80									
− 90									
−100									

Table VII.—Malleable Iron Bar.

Distances.	Deflections.							
	1.	2.	3.	4.	5.	6.	7.	8.
100								
90								
80								
70								
60	42	102	143	151	182	191	16	− 32
58	48	116	163	172	208	217	18	− 37
56	54	133	186	198	238	251	21	− 42
54	62	152	212	225	274	287	24	− 48
52	71	174	244	260	315	320	28	− 55
50	81	201	280	299	362	370	33	− 62
48	93	230	323	342	416	424	38	− 72
46	107	265	370	395	479	498	43	− 82
44	123	303	424	451	545	570	50	− 94
42	140	347	485	514	622	649	57	−106
40	158	393	545	581	700	727	65	−120
38	177	440	608	648	781	808	73	−134
36	197	488	675	717	858	888	82	−149
34	216	536	739	781	928	959	90	−164
32	234	578	796	840	988	1020	98	−176
30	249	618	845	887	1024	1062	103	−189
28	260	644	870	916	1055	1080	112	−206
26	266	660	898	932	1058	1080	112	−204
24	267	663	897	926	1035	1051	111	−203
22	263	652	861	898	987	997	110	−202
20	254	629	823	856	923	928	107	−195
18	240	596	771	799	841	847	100	−185
16	220	543	708	728	751	749	94	−172
14	199	494	636	652	657	653	85	−154
12	176	434	556	560	560	552	75	−137
10	150	371	469	475	460	457	64	−115
8	121	301	378	382	364	364	53	− 95
6	93	231	285	288	262	262	40	− 74
4	63	155	182	195	169	168	27	− 52
2	31	75	92	94	86	85	13	− 25
0	0	0	0	0	0	0	0	0
− 2	− 31							
− 4	− 62							
− 6	− 92							
− 8	−120							
− 10	−149							
− 12	−176							
− 14	−198							
− 16	−218							
− 18	−238							
− 20	−252							
− 22	−261							
− 24	−265							
− 26	−265							
− 28	−259							
− 30	−248							
− 32	−234							
− 34	−216							
− 36	−197							
− 38	−178							
− 40	−158							
− 42	−140							
− 44	−125							
− 46	−109							
− 48	− 94							
− 50	− 81							
− 52	− 71							
− 54	− 62							
− 56	− 54							
− 58	− 48							
− 60	− 42							
− 70								
− 80								
− 90								
−100								

Let—

$(\alpha+\alpha')$=the area contained by the curve 1, the axis OY or OY′, and the line YW or the line Y′W′.

α'=the area contained by the curve 2, the axis OY or OY′, and the line YV or the line Y′V′.

l=half the length of the wire or bar.

l'= half the length of the coil.

r=the distance of the middle line of the wire or bar from the magnetometer needle.

m=the sum of all the magnetic matter, northern or southern, on either side of the centre of the wire or bar.

m'=the strength of the solenoid or coil.

S=the strength of the field at the point where the magnetometer needle hangs.

θ=the angle of deflection of the needle, in radian measure, corresponding to the division of the scale.

I=the intensity of the magnetisation of the wire at any cross-section, or intensity of magnetisation of the bar at its centre.

F=the magnetising force.

μ=the magnetising susceptibility.

a=the area of the cross-section of the wire or bar.

Then it can easily be proved, provided that the angles of deflections are so small as to be proportional to their tangents, as in the case we are considering, that $2\pi r\,.\,\mathrm{S}\,.\,\theta\,.\,\alpha$ is the integral sum of all the normal components of forces over the whole surface of a cylinder whose height is the length of the wire or bar, and whose radius is r, due to the magnetic matter m, situated at the centre of the cylinder, provided the length of the wire or bar be infinitely great; the correction for this length being $2l$ instead of infinite, is such that $3m\int_0^r \frac{2\pi r\,.\,l}{(l^2+r^2)^{\frac{3}{2}}}dr$ must be added to the above quantity to get the integral in question, neglecting, however, the sum of all the normal components due to $-m$, situated in the axis of the cylinder at a distance $2l$ from its centre, over that end of the cylinder which is farthest from $-m$. But the integral of the normal force N over any closed surface due to magnetic matter m inside is,

$$\int \mathrm{N}ds=4\pi m\,;$$

hence $$2\pi r\,.\,\mathrm{S}\,.\,\theta\,.\,\alpha+3m\int_0^r \frac{2\pi r\,.\,l}{(l^2+r^2)^{\frac{3}{2}}}dr=4\pi m\,;$$

and hence $$2\pi r\,.\,\mathrm{S}\,.\,\theta\,.\,\alpha=4\pi m\left\{\tfrac{3}{2}\frac{l}{(l^2+r^2)^{\frac{1}{2}}}-\tfrac{1}{2}\right\}.$$

Let now $$\frac{r}{2}\,.\,\mathrm{S}\,.\,\theta=\mathrm{R},\ \text{and}\ \left(\tfrac{3}{2}\frac{l}{\sqrt{(l^2+r^2)}}-\tfrac{1}{2}\right)=\mathrm{P},$$

then $$\mathrm{R}\alpha=\mathrm{P}m \quad \ldots\ldots\ldots\ldots \quad (1).$$

Similarly,

$$2\pi r\,.\,\mathrm{S}\,.\,\theta\alpha'=4\pi m'\left\{\frac{l'}{\sqrt{(l'^2+r^2)}}-\tfrac{1}{2}\left(1-\frac{2l-l'}{\sqrt{[(2l-l')^2+r^2]}}\right)\right\},$$

and hence $\mathrm{R}\alpha'=\mathrm{Q}m'$, say . . . . (2),

therefore $\mathrm{R}(\alpha+\alpha')=\mathrm{P}m+\mathrm{Q}m'$,

or, $$m=\frac{\mathrm{R}}{\mathrm{P}}(\alpha+\alpha')-\frac{\mathrm{Q}}{\mathrm{P}}m' \quad \ldots\ldots \quad (3).$$

Also, $$\mathrm{I}=\frac{m}{a} \quad \ldots\ldots \quad (4),$$

and hence, in the case of thin wires,

$$\mu=\frac{m}{a\,.\,\mathrm{F}}{}^{*} \quad \ldots\ldots \quad (5).$$

The equation (2) gives us a means of ascertaining the value of m', if we know that of a', as in the case of 7 or 8, Table I. In the case where a' was not directly obtained by observation, m' was calculated from the following formula,

$$m'=c\times\mathrm{A} \quad \ldots\ldots \quad (6),$$

where A is the area contained by all the turns of coil per unit length, and c is the current strength in the coil. In the case of a cylindrical coil,

$$\mathrm{A}=n\,.\,\pi k^2+n\pi\left(\frac{2b^2\,.\,\frac{p-1}{2}\,.\,\frac{p+1}{2}\,.\,p}{2\,.\,3\,.\,p}\right)=n\pi\left(k^2+\frac{b^2(p-1)(p+1)}{12}\right);$$

in which n is the number of turns of wire per unit length of the coil, k the mean radius of the coil, p the number of layers, and b the mean distance between any two adjacent layers.

As to the evaluation of the magnetising force F. Let k be the mean radius of the cylindrical coil, or what is equivalent to it if the coil be not cylindrical; then the magnetising force at a point in the axis of the coil at a distance d from the centre, l', c, and n retaining the same signification as before, is,

$$\mathrm{F}=2\pi nc\left\{\frac{l'+d}{\sqrt{[k^2+(l'+d)^2]}}+\frac{l'-d}{\sqrt{[k^2+(l'-d)^2]}}\right\} \quad \ldots \quad (7).$$

At the centre of the coil, if l' be very great compared with k,

$$\mathrm{F}=4\pi nc \quad \ldots\ldots \quad (8).$$

Now it will be observed, as the equation (7) will show, that in my

* Papers on "Electricity and Magnetism," Sir William Thomson, p. 472; or Maxwell's "Electricity and Magnetism," vol. ii, p 68.

experiments the value of k was so very small and the magnetising force at any point of the wire or bar was so very slightly different from that at the centre, that the error which would arise from using the equation (8) will be very insignificant, and consequently this approximate equation was always used to evaluate F.

The current strength c was always measured on a Thomson tangent galvanometer, G, except when it was so weak that a small error in the galvanometer reading will produce a considerable error in the result, in which case the current was estimated from the electromotive force of the battery and the resistance of this circuit.

The strength, S, of the field was calculated in terms of H, the horizontal component of the terrestrial magnetism, simply by comparing the deflections of the magnetometer needle acted upon by a magnet (placed behind and at a convenient distance from the needle, and with its length in the line at right angles to the plane of the magnetic meridian) in the two cases: (1) When the field was due to the horizontal component H alone; and (2), when it was due to both the controlling magnet N and the horizontal force H. Since evidently the value of H seriously affects the results, it was thought desirable to make a fresh experiment to determine H at the very spot where the magnetometer needle is suspended. This was effected indirectly by counting the periods of a magnetic needle at the point in question, and at another point where the exact value of H was known from a direct experimental determination made after the manner described in my paper on "The Number of Electrostatic Units in the Electromagnetic Unit" ("Phil. Mag." for December, 1880), or more fully explained in Mr. Thomas Gray's paper on "The Experimental Determination of Magnetic Moments in Absolute Measure" ("Phil. Mag." for November, 1878); the value of H at the point where the magnetometer hangs was found to be ·1590. The value of V, the earth's vertical force, is of by far the less moment, considering that the only results the accuracy of which depends greatly upon that of the value of V, are those for μ for that particular magnetising force only; so that it was deemed unnecessary to find V by a new experiment, and consequently it was deduced from the value of H and that of the dip, 73° 45′ being taken for the latter according to the determination made some three years ago.

The final results tabulated at the end of the paper, namely, in the Tables A, B, C, D, &c., were derived from the mathematical considerations above discussed, and from the results given in the corresponding Tables of Deflection I, II, III, IV, &c., with the exception of the results given in 7, 8, 9, and 10 of the Table E, and 2, 3, and 4 of the Table F. The intensity, I, in these exceptional cases was obtained by assuming that the deflections of the magnetometer needle due to the magnetism of the bar alone (that is to say, the

deflections due to the coil being taken into consideration), corresponding to the distance 28 centims. (a distance approximately corresponding to a maximum deflection for high magnetising forces) are proportional to the intensity I. The deflections due to the coil alone were calculated from the strength of the current in the coil after a manner to be discussed later on.

Just a few words are perhaps necessary to explain the details of the Tables A, B, C, &c. In the first place the results given in the first, second, third, &c., horizontal lines along with the numbers 1, 2, 3, &c., in the Tables A, B, C, &c., correspond to the first, second, third, &c., vertical columns under the headings 1, 2, 3, &c., in the corresponding Tables of Deflection I, II, III, &c. No sign or a negative one is prefixed to the numbers, according as the polarities of the wire or bar or coil were similar or dissimilar to those induced in the wire by the earth's vertical force alone, if the numbers refer to the quantities indicating the magnetisation; or according as the magnetising forces were in a similar or dissimilar direction to the vertical force, if the numbers refer to the quantities representing the magnetising forces either directly or indirectly. Again, it will be observed that in 7 and 8 of the Table A, and of the Table C, there were obtained two values for $\frac{Q}{P}$, one calculated and the other observed; the object of this was two-fold: (1) To insure that the calculated value was within the errors of observations in the measurements of the current strengths, the dimensions of the coil, &c.; and (2), to render the results for this maximum magnetisation of the wires corresponding to these tables independent of the accuracy or inaccuracy of the measurement of the current strengths; the observed value for $\frac{Q}{P}m'$ was used, in these cases, to evaluate the quantities I, μ, &c.

The rest of what is given in the Tables A, B, C, &c., will, I hope, explain itself. But by far the readiest mode of studying the whole results, is to refer to the graphical representation shown in the Plates 11, 12, 13, 14, 15, the first three and the fourth of which contain the curves representing the "intensity of magnetisation" and the "magnetic susceptibility" respectively of the wires, and the last contains the curves representing the "intensity of magnetisation" of the bars. In other words, the curves in the Plates 11, 12, 13, and 15 are so drawn that the abscissæ are proportional to the magnetising force F, and the ordinates to the intensity I; whereas in the curves in the Plate 14 the abscissæ and the ordinates are proportional to the force F and the susceptibility μ respectively.

As regards, first of all, the Plates 11, 12, 13. The curves in the Diagram I correspond to the "Dark Wire," those in the Diagram II to the "Bright Wire," and those in the Diagram III to the "Steel Pianoforte

Wire" and "Glass-hard Steel Wire." Referring to the Diagram I, the curves (*a*) and (*b*) are those corresponding to the cases "On" and "Off" respectively directly after operating "Ons and Offs" while the magnetising force was acting; the curve (*c*) is one showing the effect of suddenly reversing the current in the coil; the curves (*d*) and (*e*) are those showing the effect of "Ons and Offs" while the reversed current was circulating through the coil, the former corresponding to the case "On" and the latter to "Off"; while the curve (*f*) is one so drawn that the ordinate at every point of it is half the algebraical difference of the ordinates of the curves (*b*) and (*c*), and hence exhibits approximately a curve which should have been obtained had the wire been experimented on without being subjected to the action of a pull. Had it not been for the sake of convenience of comparison, therefore, the curves (*c*), (*d*), and (*e*) should have been drawn on the negative side of the origin. Exactly the same explanation applies to the curves in the Diagram II as to the corresponding curves in the Diagram I.

In the Diagram III, the curves (*a*) and (*b*) show the results for "Steel Pianoforte Wire," and are subject to the same explanation as the corresponding curves (*a*) and (*b*) in the Diagram I or II; while the curves (*c*) and (*d*) refer to the "Glass-hard-tempered Wire" the former representing the result obtained when the magnetising force was in action, and the latter that obtained immediately after it was withdrawn.

Glancing at the curves in the Diagram I, we see something very striking. In the first place, we cannot help being struck with the remarkable effect of "Ons and Offs" on the magnetisation of the dark wire, when we compare the curve (*a*) or (*b*) with the curve (*f*). But a still more remarkable result is revealed in the fact that there is a surprising difference, as the curves (*a*) and (*b*) show, between the intensity of magnetisation of this wire in the case of "On," and that in the case of "Off" for low magnetising forces; and that the difference gets less and less remarkable as the magnetising force is more and more increased, becoming nothing at 15 units of the force, then changing into a negative quantity for still higher magnetising forces, and ultimately attaining a constant negative value. In other words, the intensity of magnetisation of the wire is greater or less while it is actually under the action of a constant pull than while it is free from it, according as the magnetising force to which the wire is subjected is below or above a certain value—a value which might, therefore, be called *critical.** The fact that the two pairs of curves (*d*) and (*e*)

* This confirms the result given on page 62 of Sir William Thomson's paper on the "Electrodynamic Qualities of Metals, Part VII" ("Phil. Trans.," 1879), in which he calls this value "Villari Critical Value," as having been previously obtained by Villari.

and (a) and (b) are symmetrically placed with respect to the horizontal axis, each to each, shows that the ultimate effect of "Ons and Offs," is to magnetise the wire to the same degree of intensity, under the same circumstances, whether the magnetising force be in one or in the opposite direction. On the other hand, the curve (c) shows that when the magnetising force is so high as 60 units or so the wire seems to lose its retentiveness, so much so, that the reversal of the polarities of the wire by the reversal of the force is so complete that the operation of "Ons and Offs" produced no permanent effect; but that when the magnetising force is below that value the simple reversal of the force is not so effective as to annul the permanent effects of "Ons and Offs," or even to reverse the polarities of the wire. It is obvious that the excess of the intensity of magnetisation represented by the curve (b) over that represented by the curve (f), corresponding to any magnetising force, is a measure of the retentiveness of the wire for that magnetising force.

Remarks so very similar to those made on the curves in the Diagram I apply to the corresponding curves in the Diagram II that it is quite unnecessary to mention them. The comparison of the two sets of curves in the two diagrams, however, presents many points of interest. The curves (a) and (b) in these diagrams show that for some low magnetising forces the intensity of magnetisation of the "Bright Wire" is greater than that of the "Dark Wire;" this is, perhaps, not because the former is more susceptible of magnetisation than the latter, but chiefly because of the fact that there is for each wire a certain amount of pull (used for "Ons and Offs") which would give a maximum effect on the magnetisation of the wire, and that a weight of 12 kilogs. is nearer that value for the bright wire than a weight of 8 kilogs. is for the dark wire. As regards the critical point, we see that it is about 15 units in the case of the dark wire, while it is about 10 units in the case of the bright wire; but this point is no doubt different, not only for different kinds of wire but also for different amounts of the pull. But it is in the curve (c) that the chief interest lies. The comparison of the curves (c) and (e) in the two diagrams shows that the effect of reversing the magnetising force on the change or reversal of magnetisation is considerably less in the case of the bright wire than in the case of the dark wire, both which must doubtless be accounted for by supposing that the one (tolerably soft iron) has a greater coercive force than the other (exceedingly soft iron), as might be expected.

The comparison of the curves in the Diagram III with those in the Diagram I or II is also interesting. The most striking point is that, unlike the case of soft iron wires, there is no such thing as critical point in the case of steel wire, as the curves (a) and (b) in the Diagram III point out; for every magnetising force the intensity of

magnetisation is greater in the case of "Off" than it is in the case of "On." Comparing the curves (*a*) and (*b*) in the Diagrams I, II, and III, we notice a vast difference for low magnetising forces between the intensity of magnetisation of the pianoforte wire and that of the soft iron wire; but seeing that when the magnetising force is so high as 30 units or so (when the permanent effect of "Ons and Offs" begins to be insignificant, that is, when retentiveness gets inconsiderable), the intensity of magnetisation of the steel wire is very much the same as that of the soft iron wires, I think it probable that the above difference is, in a great measure, due to the fact that a weight of 16 kilogs. (less than one-sixth of the breaking weight of the pianoforte wire) used for the operation of "Ons and Offs" is far too small to produce anything like full effect on the magnetisation of the steel wire, and that this difference can be greatly diminished by using a heavier weight (perhaps 40 or 50 kilogs.) to operate "Ons and Offs." The difference that exists between the intensity of magnetisation of the steel pianoforte wire and that of the glass-hard-tempered steel wire, corresponding to low magnetising forces, is greatly due to a similar cause; but observing that there subsists a considerable difference in the intensity of magnetisation of these two wires even for so high a magnetising force as 50 or 60 units, it seems probable that the intensity of magnetisation of the glass-hard-tempered steel wire is really smaller for every magnetising force than that of the iron-tempered steel wire, even when the effect of stress is taken into account.

As regards the limit of the magnetisation of these wires, on comparing the curves (*a*) and (*b*) in these diagrams, it will be seen that that limit is attained at so low magnetising force as 80 units or so, both in the case of the soft iron wires and the non-tempered steel wire, and that the maximum magnetisation of the pianoforte wire is not lower than that of the soft iron wires in the ordinary cases—results certainly unexpected. On the other hand, the comparison of the curves (*b*) and (*c*) in the Diagram III requires a careful study. It shows that at about 80 or even 100 units of the magnetising force there is a notable difference between the magnetisation of the non-tempered and glass-hard-tempered steel wires; but whether this difference is due to the fact that the maximum magnetisation of the latter is not yet reached at the above-stated magnetising force, or it represents the actual difference in the maximum magnetisation of the two wires, it is difficult to decide. In whichever way this difference is accounted for, it is not unfair to say that the maximum magnetisation of the glass-hard-tempered steel wire is very nearly, if indeed not exactly, equal to that of the steel pianoforte wire or the soft iron wires, and that the minimum magnetising force corresponding to the maximum magnetisation is somewhat higher in the case of the former

than in the case of the latter. The values obtained of the maximum magnetisation of these wires are as follows:—

1. The dark wire..........	I= $\begin{cases}1{,}390\\1{,}420\end{cases}$	corresponding to	"On." / "Off."
2. The bright wire.........	I= $\begin{cases}1{,}360\\1{,}415\end{cases}$	,,	"On." / "Off."
3. The steel pianoforte wire..	I= $\begin{cases}1{,}370\\1{,}420\end{cases}$	,,	"On." / "Off."
4. The glass-hard-tempered wire..............	I= $\begin{cases}1{,}400 \text{ or}\\1{,}420\,?\end{cases}$	,,	"Off."

The curve (*a*) in the Diagram III shows that the maximum residual magnetism of the tempered steel wire is considerably greater than three-fourths of the total magnetism of which it is a residue; whereas in the case of the soft iron wires the maximum residual magnetism is only a small fraction of the total magnetism.

Passing now on to the curves in the Plate 14, no more words are perhaps necessary to explain them, because the explanations given of the curves in the Plates 11, 12, 13 will exactly apply to the corresponding curves in the Plate 14, if we substitute the words "Magnetic Susceptibility" for "Intensity of Magnetisation." By the corresponding curves is meant the curves which are marked by the same letters, such as (*a*), (*b*), &c., in the diagrams designated by the same numbers, such as I, II, &c.

With regard to the results for the magnetic susceptibility, it may be remarked that the results of the preliminary experiments not given in the paper, showed that the susceptibility of any one of the wires is different according to different circumstances under which it is placed, that is to say, that there is, for each magnetising force, an infinite number of values for the susceptibility corresponding to an infinite number of amounts of pull to the applications and removals of which the wire might have been subjected (though this appears to cease to be the case when the magnetising force exceeds a certain value, that is, when the wire begins to lose its retentiveness), not to speak at all of the different values for the susceptibility the wire has at any given stage of its history, according to the different amounts of a permanent pull to which the wire may be subjected. Hence it is evident that we should have a precise knowledge of the history, past and present, of the body whose susceptibility we wish to determine; and this is the very reason why the experiments were made on the wires under definite circumstances. The two sets of the values for the susceptibility of each wire, one for the case "On," and the other for "Off," given in the corresponding table and represented by the curves, are, therefore, those corresponding to that particular circumstance under which the wire was experimented on. The magnetic susceptibility of

the soft iron wires when retentiveness is disregarded, can be calculated, if required, from the magnetisation represented by the curves (*f*), Plates 11, 12, 13.

The greatest value for the magnetic susceptibility I obtained of soft iron wire is about 730, the corresponding magnetising force being the Glasgow vertical force, and it is probably still greater for smaller magnetising forces; while the magnetic susceptibility of the same wire for so high a magnetising force as 100 units, is only about 13, and still smaller, no doubt, for higher magnetising forces. These results are truly surprising, and will dispel any doubt as to the old view that the value of μ is constant or nearly so for all or a certain range of the magnetising force.

I will now proceed to explain the curves in the Plate 15 which represent the results for the bars. The "direct curves" show the results obtained by commencing with a small magnetising force which was gradually increased until it is so high as to magnetise the bars very strongly, if not to saturation; while the "return curves" represent the results obtained by coming down from a high magnetising force to lower and lower magnetising forces, passing through the zero and going up gradually to a high magnetising force on the negative side of the zero. It may be mentioned that the reason why for the steel bar the direct curve was not obtained is because the bar, which was one of those originally intended to be used for Sir William Thomson's new Siphon Recorder, was previously magnetised strongly, and, therefore, the experiment on it was commenced by using a high magnetising force to start with; and that there is every reason to believe that the direct curve for the steel bar is something like that for the cast-iron bar.

On comparing the "direct curves" in the Plate 15, we see that the magnetisation of the cast-iron bar is somewhat less for high magnetising forces than that of the steel bar, and is much less for every magnetising force than that of the soft iron bar; and that the maximum magnetisation of the soft iron bar is about 1340, that of the steel bar is about 860, and that of the cast-iron bar is only about 770, while the corresponding least magnetising force in the case of the first is only about 190 units, and in the case of the second and third, it is roughly 450 and 400 units or more. Of course, it is not quite right to assume that the above results represent accurate comparisons of the magnetisable qualities of those different kinds of iron and steel, because the bars are not the same in dimensions, which have very considerable effects on the intensity of magnetisation. Still considering that the difference in dimensions between the soft iron bar and the other bars is very small, while in both the maximum intensity of magnetisation and the minimum magnetising force corresponding to it they differ greatly from each other, it is certain

that both the cast-iron bar and the steel bar are greatly inferior to the soft iron bar in respect to magnetisability. This is indeed unexpected, and in some measure astonishing, remembering that the steel pianoforte wire was not at all inferior in this respect to the soft iron wires, at least for higher magnetising forces. The difference that is found in the maximum intensity of magnetisation and the minimum magnetising force corresponding to that magnetisation between the soft iron bar and the wires is, however, no doubt, chiefly due to the effects of the dimensions of the bar.

Another point of interest lies in the "return curves."* They show that in the case of each bar the magnetisation of the bar did not reverse until the magnetising force exceeded a certain value on the negative side of the zero, and that this value is considerable even in the case of the soft iron bar, considerably greater in the case of the cast iron, and still greater—greater by a vast amount—in the case of the steel bar. A complete curve for the residual magnetism was only obtained, or at least only shown, for the cast iron; but the fact that those points in the return curves corresponding to the zero magnetising force represent the maximum residual magnetism of the corresponding bars, will give us a rough indication of what might be the residual magnetism curves for the other bars.

I have now given the general explanations and discussions of all the results of the experiments, and as I fear space does not permit me to enter into a fuller discussion of all the details of the results and of the inferences that can be drawn from them, I am obliged to leave them untouched. There is, however, one very interesting and important conclusion which can be derived from the results and which I cannot help noting specially, as it illustrates the beauty of this magnetometric method, and that is, in regard to the change in the distribution of magnetism of the wires or bars due to the corresponding change in the magnetising force to which they are subjected. It has already been said that one way to study the results given in the Tables I, II, &c., is to trace curves in the manner explained. Now, it is easy to get two such curves as (1) and (2) of the Plate 10 for each set of the results, one representing the effect due to both the magnetism of the wire or bar, and the coil carrying a current, and the other representing the same due to the coil alone. If we draw another curve such that its abscissa at every point of it is the difference of the abscissæ at the same point of the two curves, we obtain a curve representing the effect due to the magnetism of the wire or bar alone. The curve representing the effect of the coil alone can be easily

* Compare these curves with those given in Sir William Thomson's paper referred to before, "Phil. Trans.," 1879, Plates 8 and 9.

obtained, if necessary, from the value of m', because evidently the curve represented by the equation,

$$x=\frac{m'\,.\,r}{\mathrm{S}\,.\,\theta}\,.\left\{\frac{1}{(r^2+(l'-y)^2)^{\frac{3}{2}}}-\frac{1}{(r^2+(l'+y)^2)^{\frac{3}{2}}}\right\}\quad .\quad .\quad (9),$$

in which r, S, θ, l', &c., retain the same meaning as before, will be the one required, namely, one in which the ordinates are proportional to the vertical distances of the magnetometer needle from the centre of the coil, and the abscissæ to the deflections of the needle due to the coil.

A theoretical curve representing the effect due to the magnetism of the wire or bar solenoidally distributed, that is to say, with a certain quantity of free magnetic matter of northern polarity at one extremity and the same quantity of free magnetic matter of southern polarity at the other extremity of the wire or bar, can be obtained in a similar way; in fact, the equation (9) will represent such a curve, if we substitute the quantity of the free magnetic matter at either end of the wire or bar for m' and half the length of the wire or bar for l'.

Now the curves (1), (2), (3), and (4), in the Plate 16, were obtained in the way just explained from the results given in 1, 2, 4, and 7, and the Tables I and II (that is, the results for the "Dark Wire"); they represent the curves showing the effects due to the magnetism of the wire alone, and correspond respectively to ·545 (in vertical force), 2·35, 14·08, and 80·7 units of the magnetising force, while (5) is a theoretical curve representing the effect which should have been obtained had the same wire been magnetised solenoidally, so as to contain 8 units of the quantity of free magnetic matter of one polarity at one end of it, and the same quantity of matter of opposite polarity at the other end. These curves form the true comparisons of the magnetisations of the wire in the different cases, because they are all reduced to the same standard, that is to say, they are all so drawn that their abscissæ represent the deflections of the magnetometer needle which should have been obtained had the field S been one and the same, namely, 1·873 units in all cases.

The comparisons of the curves (1), (2), (3), and (4) show that the greater the magnetising force the greater is the distance from the centre or origin of the points of the ordinates corresponding to the maximum deflections of the magnetometer needle, while the comparison of the curves (4) and (5) shows that these points in the case of the curve (4) are almost, if not exactly, coinciding with those in the case of (5); showing quite distinctly that the magnetisation of the wire for a low magnetising force is far from being solenoidal, but stronger at the central parts of the wire than in the other parts; but that as this force is made stronger and stronger, the magnetism of the wire becomes more and more equally distributed to the ends until the dis-

tribution becomes nearly, if not altogether, solenoidal, when the force is made so high as to give the wire the maximum magnetisation. More or less similar facts can be arrived at from the results for other wires, and also those for the bars.

These facts are truly interesting, seeing that they entirely agree with theoretical considerations. Indeed they have been pointed out theoretically by Sir William Thomson,* and indicated experimentally by Rowland.† But I believe my experiments are the first, the results of which have brought out those facts so clearly as not only to leave no room for doubt, but also to enable us to see the law by which the change in the distribution of magnetism in a cylindrical rod due to the change of magnetising force to which it is subjected, is governed; and I hope they will be of service in guiding the future investigators of electro-magnetism or otherwise.

It is impossible for me to conclude this paper without expressing my most grateful thanks to Sir William Thomson for the very kind guidance and instruction he has given me in the course of these experiments.

* Papers on "Electricity and Magnetism," § 667.

† "Phil. Mag.," August, 1873, p. 142.

Table A.—Dark Soft Iron Wire.

Number of heading under deflection in Table I.	S.	$\alpha+\alpha'$.	c.	$\frac{R}{P}(\alpha+\alpha')$.	$\frac{Qm'}{P}$. Calculated.	$\frac{Qm'}{P}$. Observed.	m.	I.	F.	μ.
1........	H = 0·1590	8,340	0	1·704	0	..	1·704	400	V = 0·545	734
	,,	3,800	0	0·7766	0	..	0·7766	182	,,	335
2........	,,	11,740	0·00865	2·400	0·0522	..	2·348	551	1·806 + V = 2·35	235
	,,	7,780	,,	1·590	,,	..	1·538	361	,,	154
3........	,,	16,070	0·0229	3·283	0·138	..	3·145	738	5·33	139
	,,	12,320	,,	2·518	,,	..	2·380	559	,,	105
4........	H × 11·92 = 1·895	1,880	0·0[illegible]48	4·566	0·3914	..	4·175	980	14·08	69·[illegible]
	,,	1,830	,,	4·445	,,	..	4·054	952	,,	67·6
5........	,,	2,500	Mean = 0·1605	6·071	0·969	..	5·102	1266	34·07	35·2
	,,	2,620	,,	6·363	,,	..	5·394	1198	,,	37·2
6........	H × 11·78 = 1·873 ,,	3,930	0·0538	9·441	3·648	..	5·793	1360	56·7	24·0
7........	,,	4,600	Varied between	11·08	5·21	..	5·93	1390	80·7	17·1
	,,	4,670	,,	11·24	,,	..	6·09	1430	,,	17·6
	,,	2,180	,,	..	..	5·15				

Table A (continued).—Dark Soft Iron Wire.

Number of heading under deflection in Table I.	S.	$\alpha+\alpha'$.	c.	$\frac{R}{P}(\alpha+\alpha')$.	$\frac{Q}{P}m'$. Calculated.	$\frac{Q}{P}m'$. Observed.	m.	I.	F.	μ.
8........	H × 11·78 = 1·873	5,270	.. ..	12·69	6·80	..	5·93	1390	105	13·2
	”	5,330	Varied between	12·82	”	..	6·05	1420	”	13·5
	”	2,810	”	..	..	6·76				
12........	”	−2,335	−0·0196	−5·622	−1·329	..	−4·293	−1010	−19·9	
	”	−2,420	”	−5·731	−1·329	..	−4·403	−1060	”	
	”	−2,510	”	−6·043	”	..	−4·714	−1110	”	
13........	”	−1,630	−0·0109	−3·924	−0·739	..	−3·185	− 748	−10·7	
	”	−1,930	”	−4·647	”	..	−3·908	− 917	”	
	”	−1,870	”	−4·502	”	..	−3·763	− 833	”	
14........	”	−1,110	−0·00684	−2·673	−0·464	..	−2·209	− 518	−6·60	
	”	−1,460	”	−3·516	”	..	−3·052	− 716	”	
15........	H = 0·1590	−5,555	−0·00341	−1·135	−0·231	..	−0·904	− 212	−3·015	
	”	−10,840	”	−2·216	”	..	−1·995	− 467	”	
16........	”	3,900	−0·000928	0·797	−0·0629	..	0·860	202	−0·424	
	”	−3,770	”	−0·7703	”	..	−0·707	− 166	−0·424	
17........	”	4,630	−0·000785	0·946	−0·0532	..	0·999	234	−0·275	
	”	−1,660	”	−0·339	”	..	−0·286	− 67·1	”	

Table B.—Bright Wire.

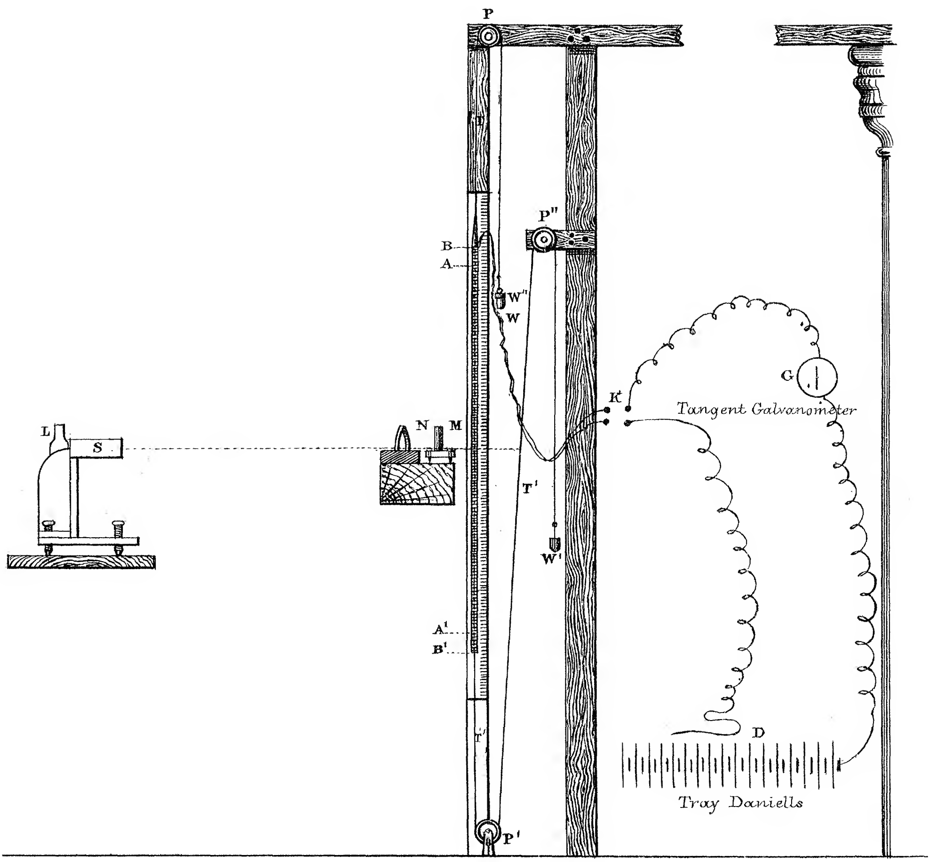
Number of heading under deflection in Table II.	S.	$\alpha+\alpha'$.	c.	$\frac{R}{P}(\alpha+\alpha')$	$\frac{Q}{P}m'$. Calculated.	$\frac{Q}{P}m'$. Observed.	m.	I.	F.	μ.
1........	H = ·1590	9630	0	1·966	0	..	1·966	328	V = 0·545	602
	H = ·1590	6710	0	1·370	0	..	1·370	228	„	419
	„	5290	0	1·080	0	..	1·080	181	„	
	„	−5690	0	−1·366	0	..	−1·366	−227	„	
2........	H × 11·7 = 1·860	1470	0·001686	3·513	0·114	..	3·399	567	2·31	245
	„	898	„	2·146	„	..	2·032	340	−1·21	
3........	„	2410	0·00341	5·758	0·231	..	5·527	923	4·11	225
	„	2040	0·00341	4·874	0·231	..	4·643	776	4·11	188
	„	550	−0·00341	1·314	−0·231	..	1·543	251	−3·01	
	„	−1840	−0·00341	−4·396	−0·231	..	−4·165	−696	−3·01	
4........	„	2730	0·00702	6·524	0·476	..	6·048	1010	7·87	127
	„	2620	0·00702	6·261	0·476	..	5·785	950	7·87	120
	„	− 870	−0·00702	−2·079	−0·476	..	−1·603	−267	−6·78	
	„	−2540	0·00702	−6·068	−0·476	..	−5·592	−931	−6·78	
5........	„	3130	0·0141	7·478	1·008	..	6·470	1090	15·00	73·5
	„	3350	„	8·004	„	..	6·996	1180	15·0	79
	„	−2540	−0·0141	−6·068	−1·008	..	−5·060	−857	−13·8	
	„	−3310	„	−7·909	„	..	−6·901	−1165	„	

Table B (continued).—Bright Wire.

Number of heading under deflection in Table II.	S.	$\alpha+\alpha'$.	c.	$\frac{R}{P}(\alpha+\alpha.)$	$\frac{Q}{P}m'$.		m.	I.	F.	μ.
					Calculated.	Observed.				
6........	H × 11·7 = 1·860	3790	Mean = ·0276	9·055	1·871	..	7·244	1210	29·4	41·1
	”	3980	”	9·510	”	..	7·639	1275	”	43·3
	”	−3800	Mean = − ·0276	−9·081	−1·871	..	−7·210	−1205	−28·3	
	”	−3920	”	−9·367	”	..	−7·496	−1220	−28·3	
7........	”									
	”	5000	Varied between ·0558 and ·0552 Mean = ·0555	11·95	3·76	..	8·19	1370	58·4	23·3
	”	−4980	Mean = − ·0555	−11·90	−3·76	..	−8·14	−1360	−57·4	
	”	−5000	”	−11·95	”	..	−8·19	−1370	”	
8........	”	5540	Varied between ·0805 and ·0790 Mean = 0·0798	13·23	5·41	..	7·82	1320	83·9	15·7
	”	5790	”	13·84	5·41	..	8·43	1410	”	16·8
	”	−5540	Mean = − ·0798	−13·23	−5·41	..	−8·43	−1410	−82·8	
9........	”	6420	Varied between ·1025 and ·1005 Mean = ·1015	15·34	6·88	..	8·46	+1415	106·5	13·3

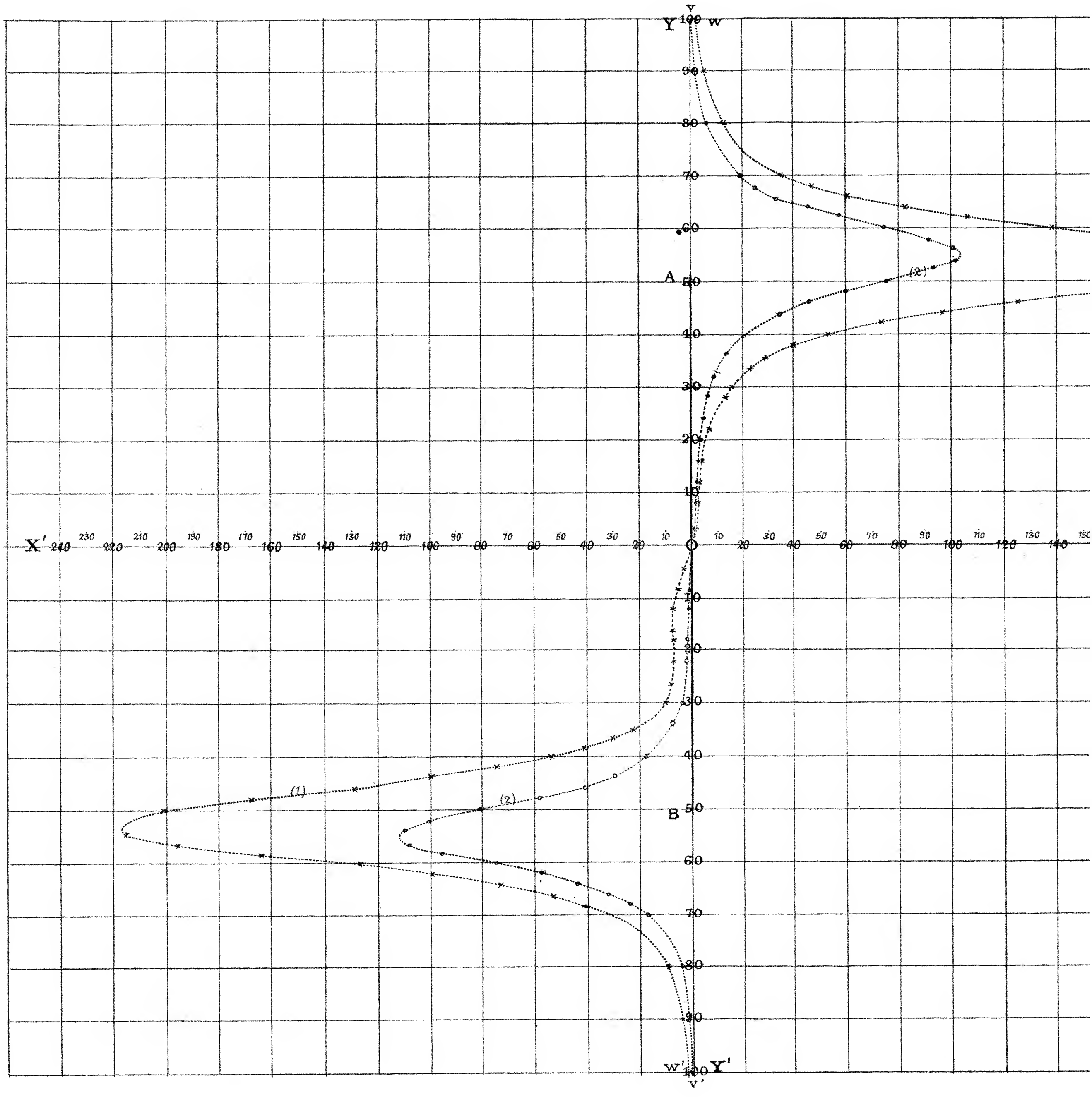
Table C.—Pianoforte Wire.

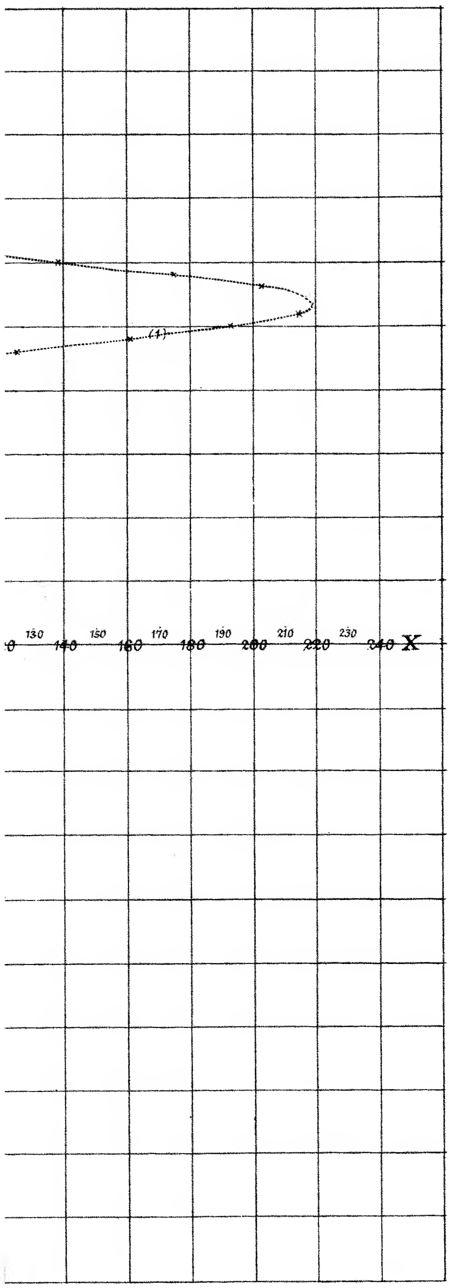
Number of heading under deflection in Table III.	S.	$\alpha+\alpha'$.	c.	$\frac{R}{P}(\alpha+\alpha')$.	$\frac{Q}{P}m'$. Calculated.	$\frac{Q}{P}m'$. Observed.	m.	I.	F.	μ.
1........	H = 0·1590	800	0	0·1637	0	..	0·1637	37·8	V = ·545	67·5
	”	820	0	0·1678	0	..	0·1678	38·6	”	69·3
2........	”	3570	0·00338	0·7305	0·229	..	0·5015	112·7	4·074	27·6
	”	3840	”	0·7856	”	..	0·5566	125	”	30·7
3........	”	7410	0·00704	1·517	0·477	..	1·040	233	7·89	29·6
	”	8070	”	1·651	”	..	1·174	258	”	33·4
4........	H × 11·7 = 1·860	1300	0·0142	3·113	0·963	..	2·150	484	14·8	31·6
	”	1340	”	3·209	”	..	2·246	504	”	33·0
5........	”	2960	0·0288	7·089	1·953	..	5·036	1132	30·6	37·0
	”	3130	”	7·496	”	..	5·543	1245	”	40·7
6........	”	3950	·0552	9·461	3·743	..	5·718	1284	58·2	22·1
	”	4110	”	9·842	”	..	6·099	1370	”	23·5
7........	”	4820	Varied between ·0783 & ·0773 Mean = ·0778	11·54	5·28	..	6·30	1415	81·7	17·3
	”	2190	”	..	..	5·24				
8........	”	5540	Varied between ·1036 & ·1014 Mean = ·1025	13·23	6·95	..	6·33	1420	107·5	13·2
	”	2880	”	..	..	6·95				



West Newman & Co. lith.

Shida.

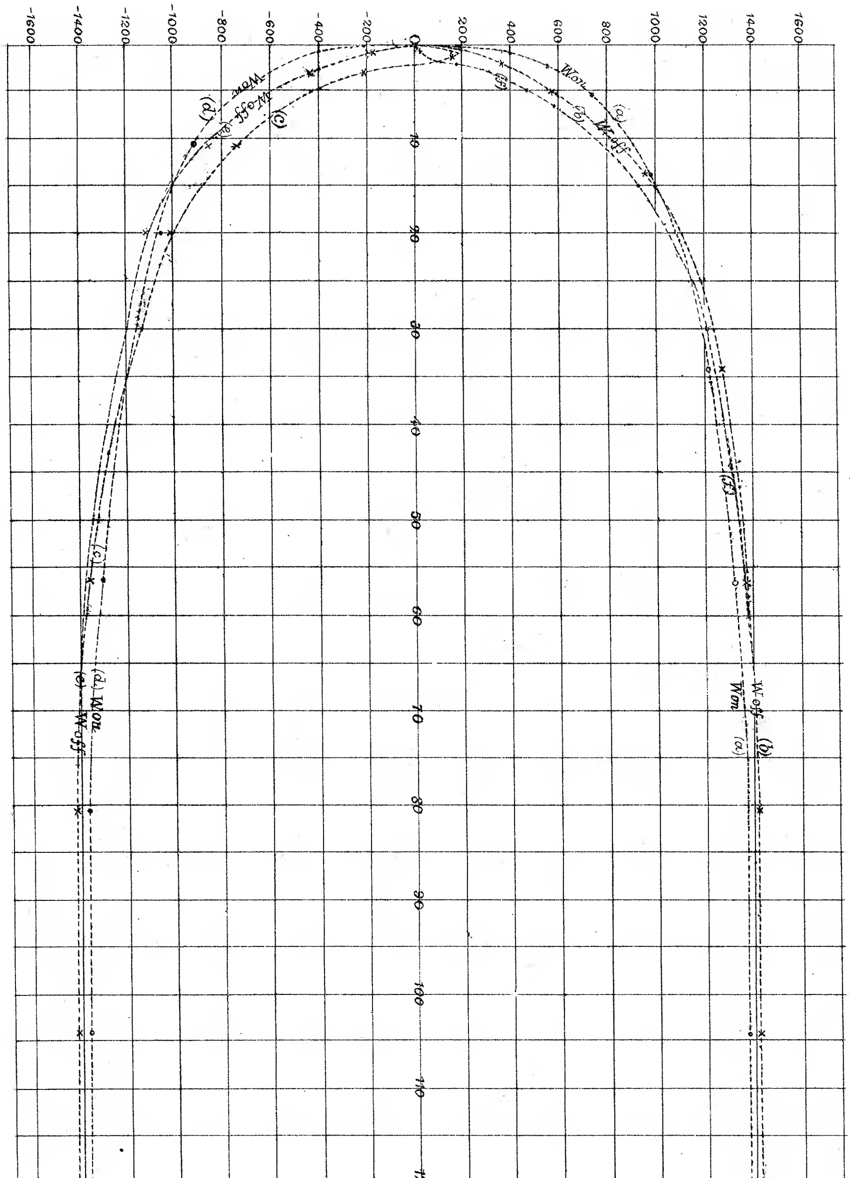




West Newman & C° lith.

Intensity of Magnetization - Curves.

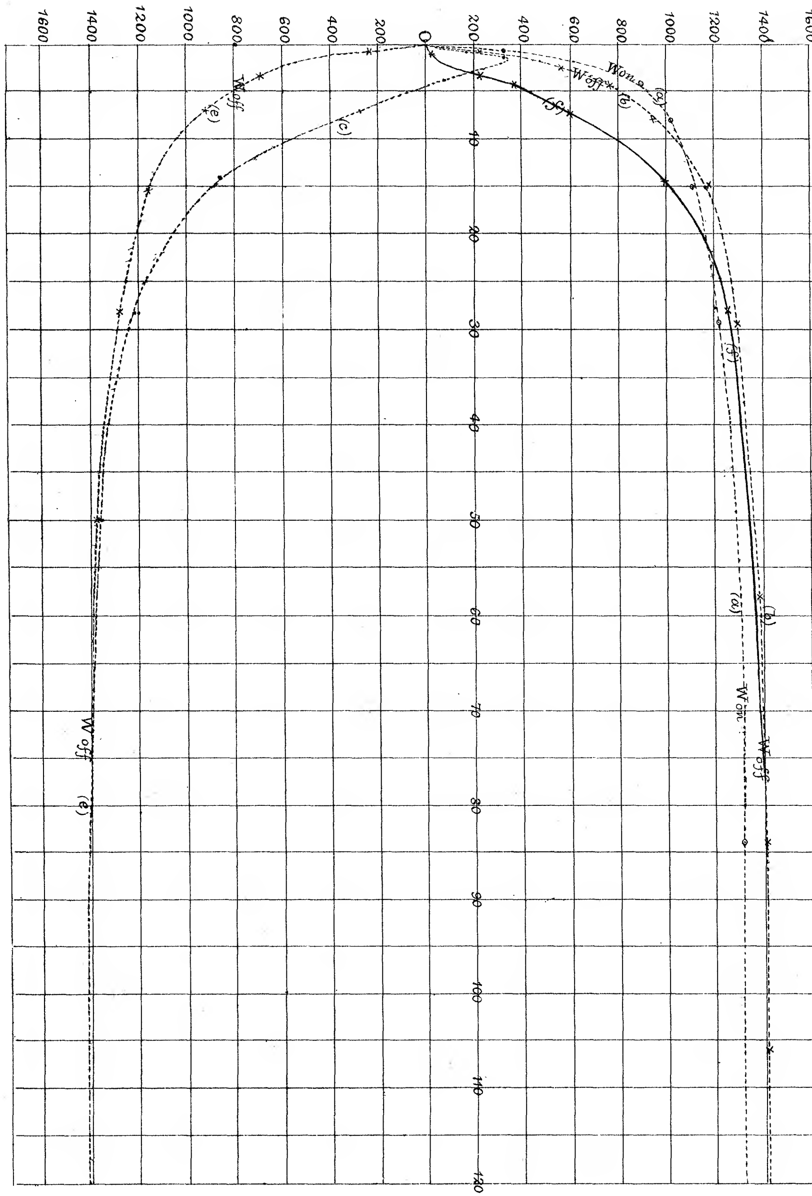
DIAGRAM I. (*Dark wire. — W = 8 kilogs.*)



West Newman & C° lith.

Intensity of Magnetization - Curves.

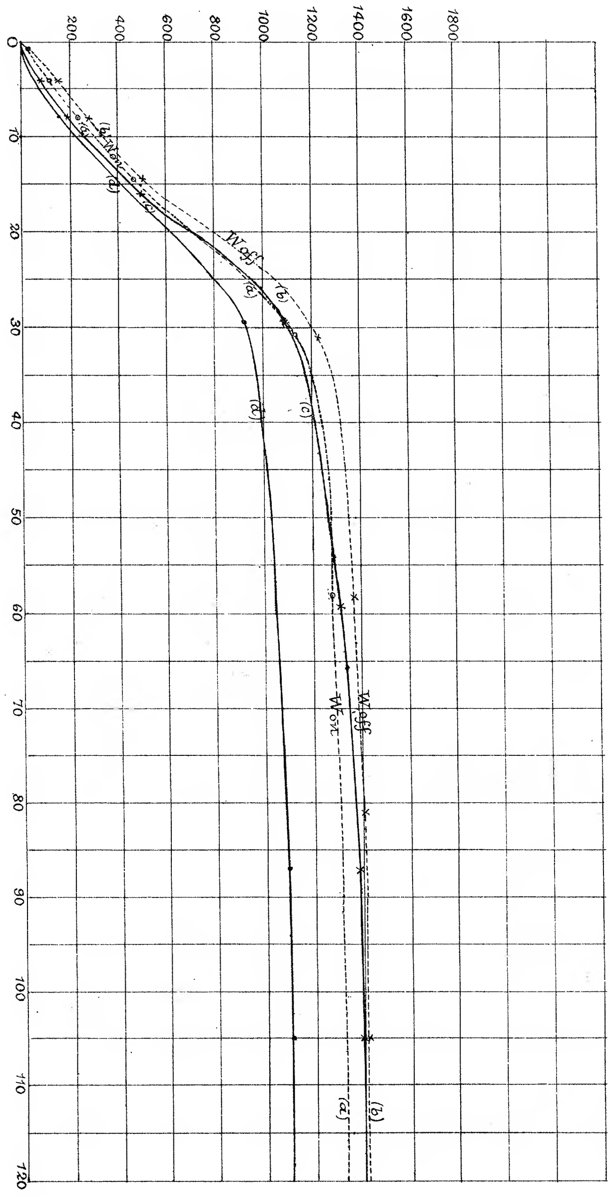
DIAGRAM II. (Bright wire — W = 8 kilogs.)



West Newman & Co. lith.

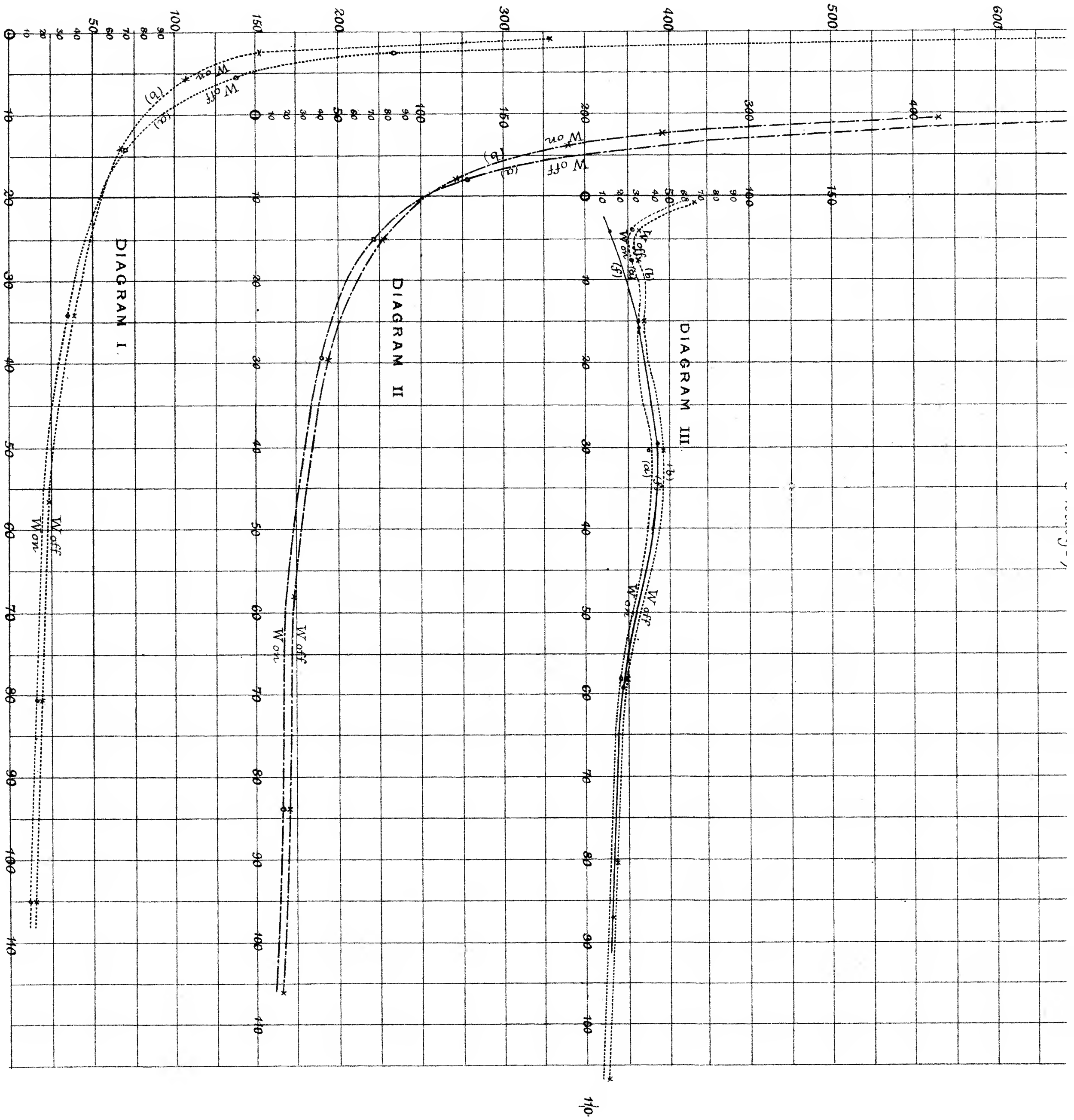
"Intensity of Magnetization - Curves.

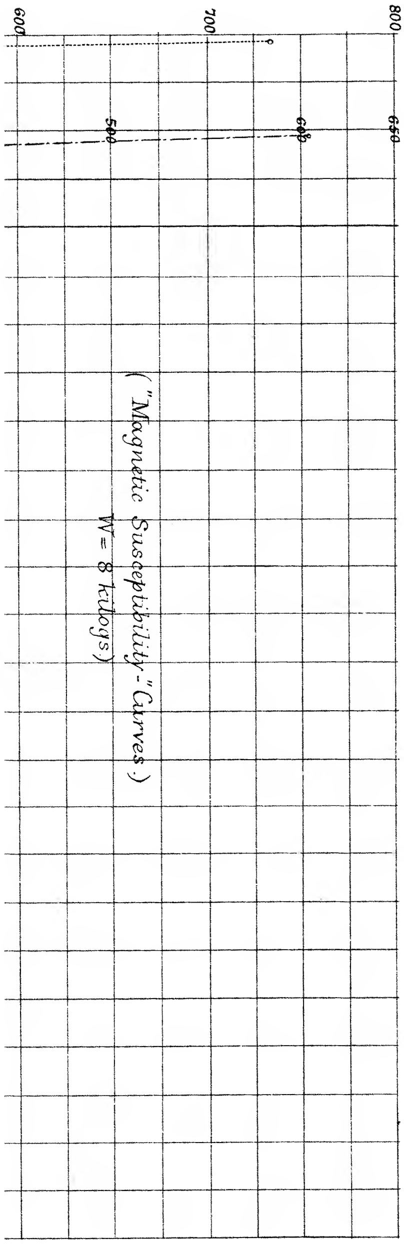
DIAGRAM III. (Non-tempered and tempered Steel Pianoforte-wire) W = 8 kilogs



West Newman & Co. lith.

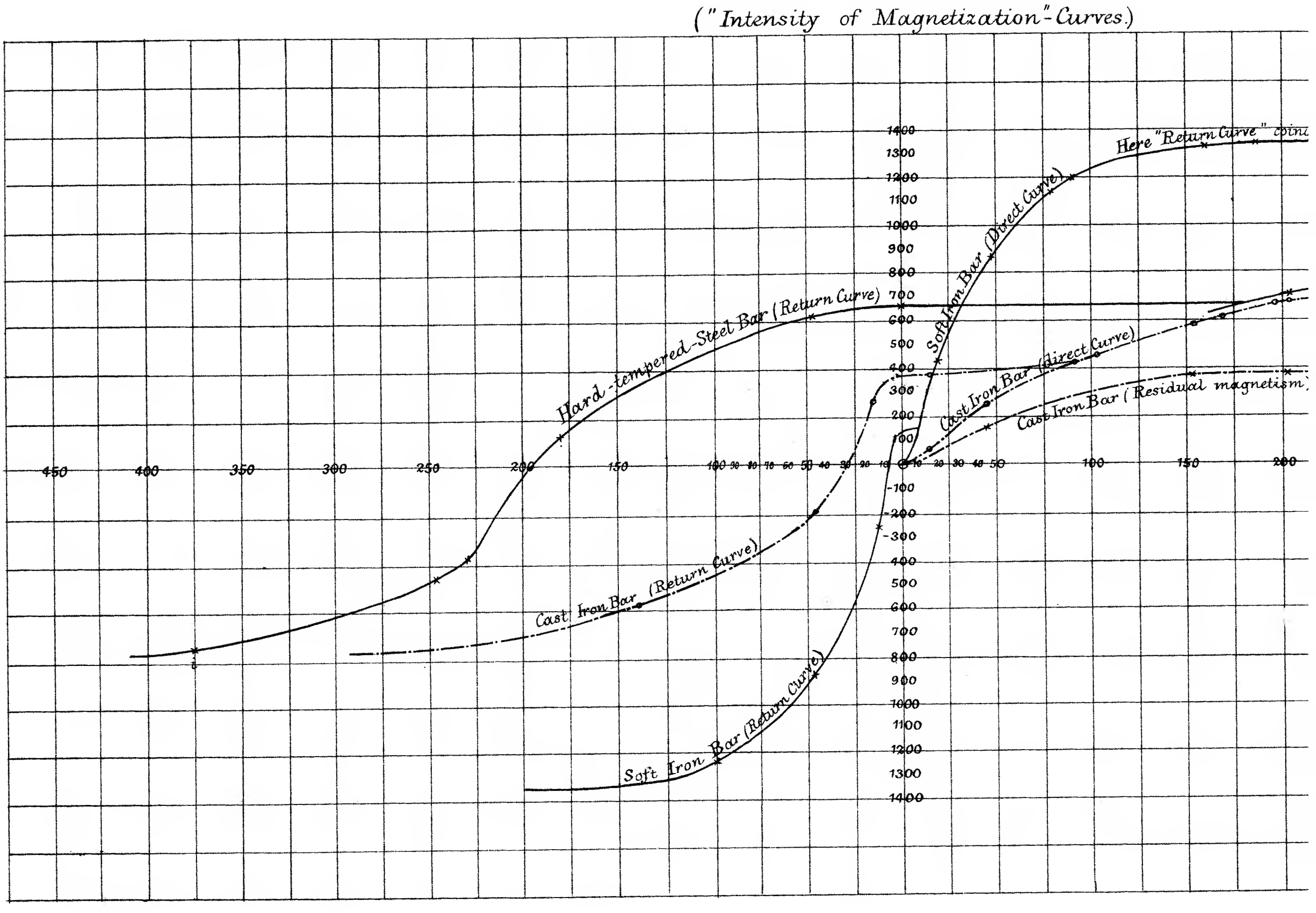
Shida.



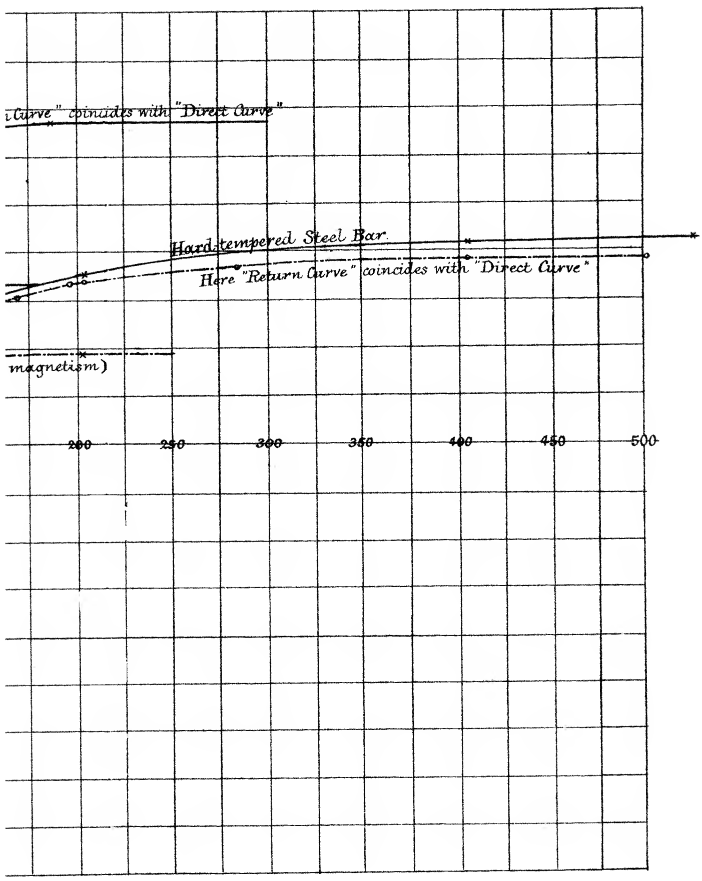


West Newman & C° lith.

Shida.

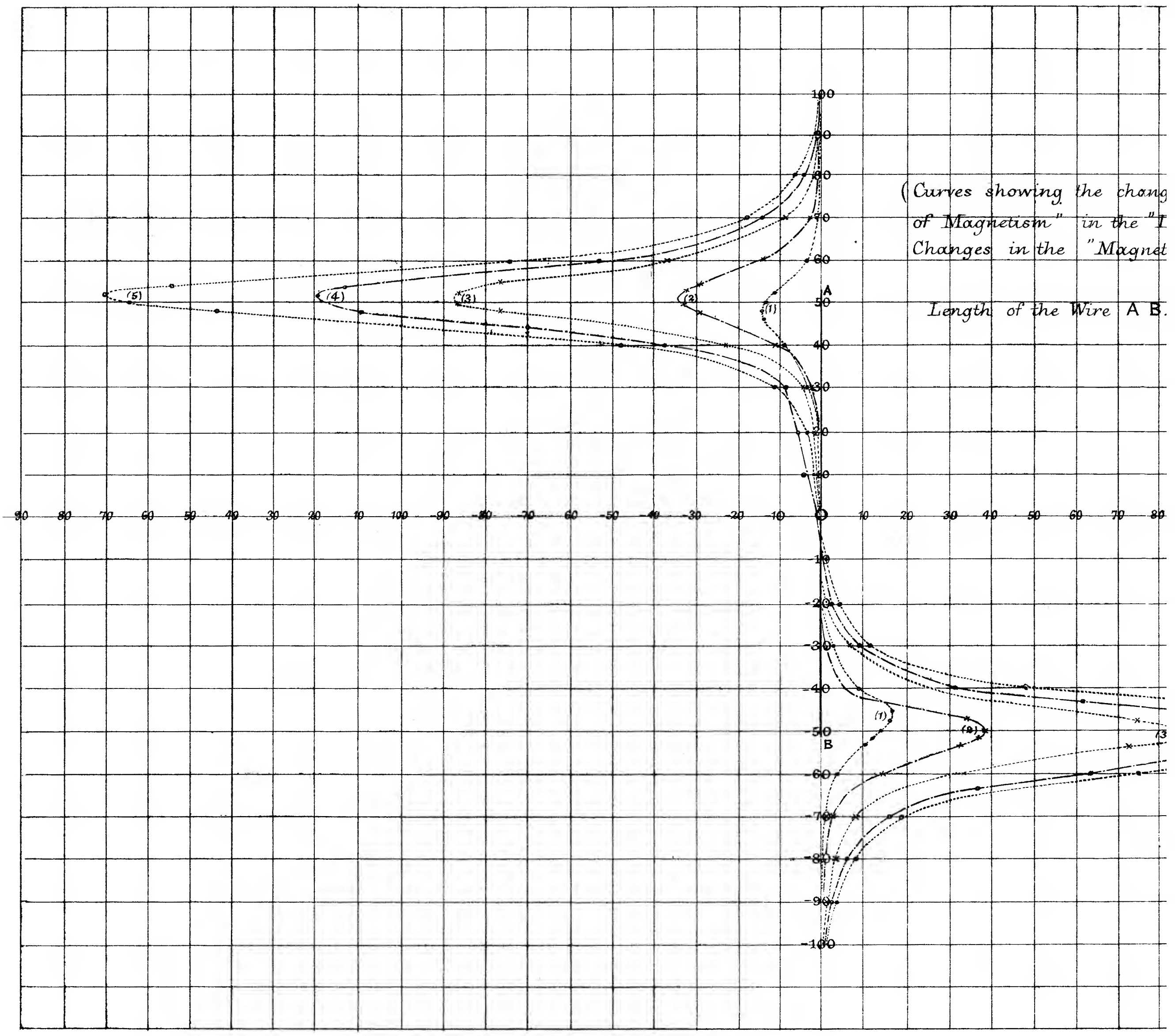


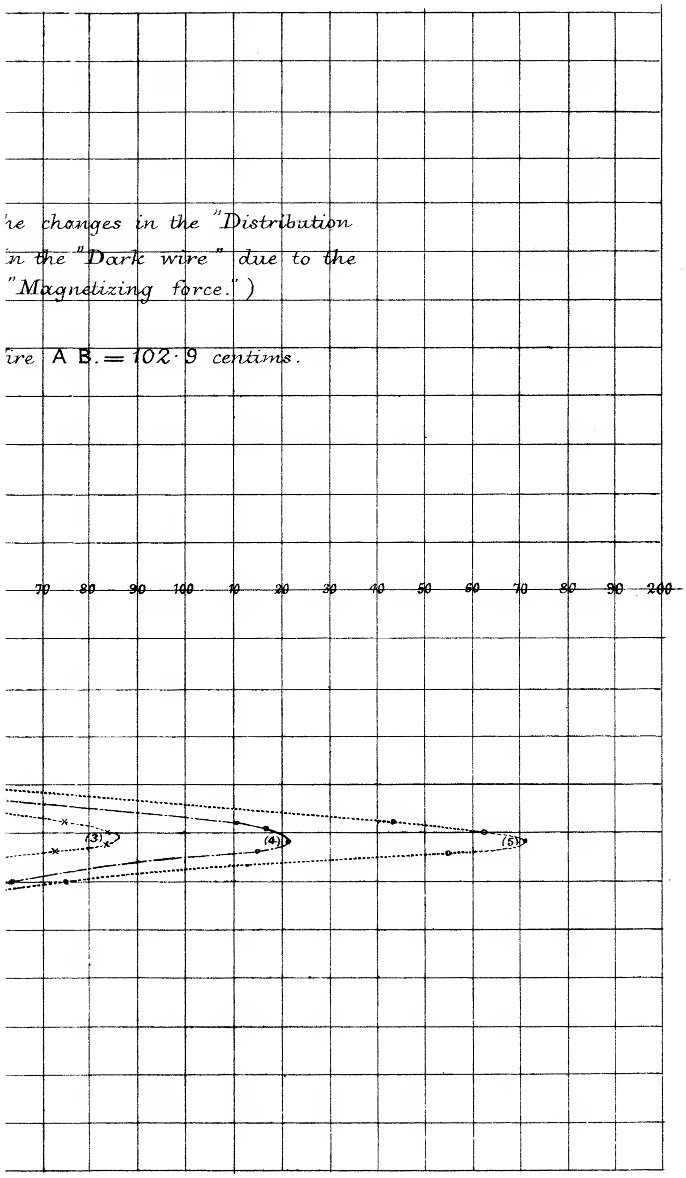
("Intensity of Magnetization"-Curves.)
Here "Return Curve" coinc
Hard-tempered-Steel Bar (Return Curve)
Soft Iron Bar (Direct Curve)
Cast Iron Bar (direct Curve)
Cast Iron Bar (Residual magnetism)
Cast Iron Bar (Return Curve)
Soft Iron Bar (Return Curve)
450
400
350
300
250
200
150
100
50
10
20
30
40
50
100
150
200
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
-100
-200
-300
400
500
600
700
800
900
1000
1100
1200
1300
1400



West Newman & C° lith.

Shida.


(Curves showing the chang
of Magnetism" in the "I
Changes in the "Magnet
Length of the Wire A B.
A
B
(1)
(2)
(3)
(4)
(5)



West, Newman & Co. lith.

Table D.—Glass-hard-tempered Wire.

Number of heading under deflection in Table IV.	S.	$\alpha+\alpha'$.	c.	$\frac{R}{P}(\alpha+\alpha')$.	$\frac{Q}{P}m'$. Calculated.	$\frac{Q}{P}m'$. Observed.	m.	I.	F.	μ.
1....	H = 0·159	2300	0·00328	0·4796	0·2201	..	0·2595	59·4	3·97	15·0
2..........	H × 11·7 = 1·860	1334	0·0149	3·245	0·980	..	2·265	519	15·8	32·8
3........ {	,, ,,	2730 1670	0·0276 0	6·662 4·075	1·852 0	.. ..	4·81 4·075	1100 930	29·4 0	37·5
4..........	,,	3880	0·0563	9·491	3·778	..	5·713	1310	59·3	22·1
5........ {	,, ,,	4760 1960	Mean = ·0825 0	11·61 4·783	5·54 0	.. ..	6·07 4·783	1390 1090	86·7 0	16·0
6........ {	,, ,,	5290 1960	Mean = ·1015 0	12·91 4·783	6·81 0	.. ..	6·10 ..	1400 1090	106·4 0	13·3

Table E.—Cast-Iron Bar.

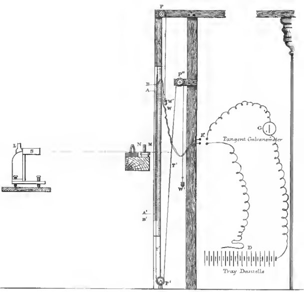
Number of heading under deflection in Table V.	S.	$a+a'$.	c.	$\frac{R}{P}(a+\alpha)$.	$\frac{Q}{P}m'$.	m.	I.	F.
1	8·835	1,750	0·0424	59·33	3·62	55·71	58·6	14·6
2	,,	7,180	Varied from ·133 to ·131 Mean = ·132	243·4	11·3	232·1	244	45·4
	,,	4,320	0	147·5	0	147·5	155	,,
3	,,	13,560	Varied from ·312 to ·286 Mean = ·299	459·7	25·5	434·2	457	103
4	,,	17,380	Varied from ·470 to ·430 Mean = ·450	589·2	38·4	550·8	579·8	155
	,,	10,310	0	349·5	0	349·5	368	,,
5	,,	18,600	Varied from ·534 to ·462 Mean = ·498	630·6	42·5	588·1	619	171
6	,,	20,050	Varied from ·624 to ·524 Mean = ·574	679·8	49	630·8	664	197
	,,	10,940	,,	371	0	371	390	,,
7	,,	...	0·610	...	...	...	672	208
8	,,	...	0·920	...	...	...	731	316
9	,,	...	1·250	...	...	...	765	430
10	,,	...	1·460	...	...	...	767	502
11	,,	11,160	0·042	378·4	3·59	374·8	394·6	14·4
12	,,	7,820	−0·0392	265·2	− 3·37	268·6	283	− 13·6
13	,,	− 5,560	Varied from ·130 to ·128 Mean = −·129	−188·6	−11	−177·6	−187	− 44·4
14	,,	−17,300	Varied from ·43 to ·39 Mean = −·410	−586	−35	−551·5	−580	−141

Table F.—Steel Bar, Hard-tempered.

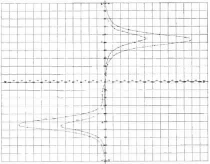
Number of heading under deflection in Table VI.	S.	$\alpha+\alpha'$.	c.	$\frac{R}{P}(\alpha+\alpha')$.	$\frac{Q}{P}m'$.	m.	I.	F.
1................	8·835	20,750	Varied between ·608 and ·580 Mean = ·594	703·7	50·74	653	689	205
2................	,,	..	1·18	..	..	..	815	406
3................	,,	..	1·54	..	..	..	867	526
4................	,,	..	1·82	..	..	..	867	626
5................	8·06	20,190	0	624·4	0	624·4	659	0
6................	,,	18,470	−0·142	571·2	−12·13	583·3	613	− 48·8
7................	,,	2,320	Varied between ·537 and ·505 Mean = ·521	71·76	−44·5	116·3	123	−179
8................	,,	−12,620	Varied between ·696 and ·632 Mean = ·664	−390·4	−56·7	−333·7	−352	−228
9................	,,	−15,480	Varied between ·742 and ·680 Mean = ·711	−478·7	−60·7	−418	−441	−244

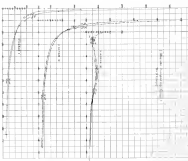
Table G.—Malleable Iron Bar.

Number of heading under deflection in Table VII.	S.	$\alpha+\alpha'$.	c.	$\frac{R}{P}(\alpha+\alpha')$	$\frac{Q}{P}m'$.	m.	I.	F.
1..........	8·835	9,260	·053	313·9	4·53	309·4	343	18·2
2..........	„	23,050	·139	781·4	11·9	769·5	854	47·8
3..........	„	30,930	Varied between ·238 and ·218 Mean = ·228	1049	19·5	1030	1143	78·4
4..........	„	32,340	Varied between ·266 and ·252 Mean = ·259	1096	22·1	1074	1192	89·0
5..........	„	36,640	Varied between ·490 and ·450 Mean = ·470	1243	40·1	1203	1336	163
6..........	„	37,030	Varied between ·594 and ·544 Mean = ·570	1255	48·7	1206	1339	189
7..........	„	−7,150	− ·053	−242·4	−4·5	−237·9	−264	− 18·2
8..........		−23,050	− ·139	−781·4	−11·9	−769·5	−854	−47·8

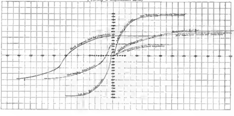


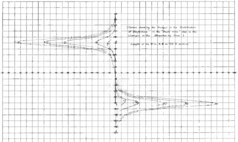
P
P''
B
A
W''
W
G
K'
Tangent Galvanometer
L
S
N
M
T'
W'
A'
B'
D
Tray Daniells
P'





("Intensity of Magnetisation" Curves)




(Curves showing the changes in the Distribution of Magnetism in the "Iron wire" due to the changes in the Magnetizing Force.)
Length of the Wire A B = 12.8 centims